PROCEEDINGS

of the

American Society

of

Civil Engineers

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CONTENTS

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SOCIETY AFFAIRS

CONTENTS

AMERICAN SOCIETY OF CIVIL ENGINEERS

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VOL. LII MARCH, 1926 NO. 3

SOCIETY AFFAIRS

Error in Announcement of 1926 Annual Convention

Attention of members is called to the error on the cover-pages of the February, 1926, *Proceedings,* in announcing the 1926 Annual Convention for Seattle, Wash.

In order to correct any misunderstanding that may have occurred, the schedule of meetings for 1926 is as follows:

Spring Meeting............... Kansas City, Mo., April 14-16, 1926.
Summer Meeting............. Seattle, Wash., July 14-16, 1926.
Fifty-Sixth Annual Convention. Philadelphia, Pa., October 4-9, 1926.

Leonard Metcalf

In the passing of Leonard Metcalf, M. Am. Soc. C. E., who died at Concord, Mass., on February 1, 1926, the Society lost one of its most prominent and active members.

Mr. Metcalf was born at Galveston, Tex., on August 26, 1870, and was graduated from the Massachusetts Institute of Technology in 1892. He was elected a Member of the Society in 1903, and served as a Director from 1913 to 1915 and as Vice-President in 1919 and 1920.

Practically all Mr. Metcalf's professional career had been devoted to practice in Water-works, Sewerage, and Utility Valuation, From 1892 to 1895 he was associated with Wheeler and Parks of Boston, Mass., on water-works construction and operation in New England, Kentucky, and Tennessee. Then, for two years, he was Professor of Mathematics and Engineering at the Massachusetts Agricultural College. Returning to private practice in 1897, Mr. Metcalf established headquarters in Boston, and, in 1907, became one of the senior partners of the firm of Metcalf and Eddy, with which firm he was associated at the time of his death.

During the World War he was a member of the Sub-Committee on Emergency Construction of Buildings and Engineering Structures under the National Council of Defense.

In addition to his membership in the Society, Mr. Metcalf was affiliated with many technical organizations, among which were: American Society of Mechanical Engineers; Past-President, American Water Works Association; Past-President and Honorary Member, New England Water Works Association; and Past-President, Boston Society of Engineers.

The Engineer and His Income Tax

Engineers in common with others should be interested in taking advantage of all the legitimate deductions to be made in the Federal Income Tax. The following interpretations of the Law, verified by an expert, are presented to the members as a possible aid in pointing out deductions that the Government recognizes as legitimate.

State and Municipal Employees.—Employees of States and political subdivisions thereof are exempt from tax on incomes received from such States and political subdivisions. This is not to be construed as applying to engineers who act in a consulting capacity nor has it yet been positively determined with regard to employees of municipally operated utilities concerning which rulings are now pending in the Courts.

On January 11, 1926, the U. S. Supreme Court sustained the decision of the lower Courts in the test case conducted by the firm of Metcalf and Eddy. The essence of the decision of the Supreme Court was briefly that income received by consulting engineers from Federal, State, or Municipal Governments is taxable unless they are regular employees or officials thereof. *Engineering News-Record* of August 13, and October 8, 1925, and January 14 and 21, 1926, published articles dealing with this case and the scope of the decision as affecting engineers employed on municipal railways and water-works.

Society Dues.—Dues to charitable and professional organizations not run for profit are among the deductions permitted before computing the tax. This includes all the Society dues paid during the taxable year. Payment for compounding dues in advance (as authorized by the Constitution of the Society, or according to the recently effected plan for Paid-Up Dues) is also considered to be deductible. Such reductions apply to the calendar year in which the payment was made. In the Income Tax blank entry for this amount should be made under business expense.

Supplies, etc.—Engineers may also claim as deductions the cost of supplies used in the practice of the profession, expenses paid in the operation and repair of automobiles used in making professional calls, subscriptions to professional journals, the rent paid for office rooms, the expense of the fuel, light, water, telephone, etc., used in such offices, and the hire of office assistants. Amounts currently expended for books, furniture, and professional instruments and equipment, the useful life of which is short, may also be deducted.

Bad Debts.—Bad debts are deductible, the only question involved being the determination of the fact that they are unrecoverable. Conversely, any bad debt, which has been charged off and taken as a deduction and is later paid, becomes taxable as income.

Neither the Act nor the Regulations promulgated by the Internal Revenue Bureau set forth the manner in which a bad debt is to be determined as "worthless". The law is silent on this important point and, therefore, it must be left to the discretion of the person making his returns and if that discretion is used fairly and honestly, there would seem to be no just ground for complaint. It can scarcely be contended that every debt must be ascertained to be worthless by a suit at law or in equity, for that would be impractical. However, a debt may not be charged off as "worthless" until the taxpayer has taken all reasonable steps to determine that there is no probability of payment or collection and has *prima facie* evidence to prove that the debt has no value. A creditor, unaware of the financial status of his debtor, who has exhausted all ordinary means for the recovery of an account so that any further attempt to collect the balance due would entail an expense in excess of the amount involved, may deduct the uncollectable balance as a bad debt in his return for the year in which found to be uncollectable and charged off.

Other Deductions.—Among the deductible items often overlooked may be mentioned: Automobile license fees; chauffeur's license; bonus to employees when paid as additional compensation and not made as a gift; all State taxes, including State income tax; various other taxes, such as those on club dues, theatre or opera tickets, stock transfers, personal property, and residence owned, but not Federal Income Tax; traveling expenses, such as railroad fares, meals, and lodging, if the trip is solely for business purposes; and entertainment, provided the taxpayer can show evidence that amounts expended for this purpose were spent upon prospective clients.

It is hoped that the foregoing may be of value. If difficulty is experienced in making out the return after having carefully read and followed the instructions, members should consult the officers of their bank.

Annual Business Meeting of the Society

The Seventy-third Annual Meeting of the Society was called to order at 10:20 A. M., by President Robert Ridgway. Tellers to canvass the ballot for Officers were appointed, following which the reports of the Board of Direction, the Secretary, and the Treasurer, were read. At the request of the President those present stood for a few moments in silence as a tribute to the officers and members who had died during the year.

Honorary membership was conferred on William Barclay Parsons, M. Am. Soc. C. E., and Arthur N. Talbot, Past-President, Am. Soc. C. E., who expressed their appreciation of the honor bestowed on them by the Society. Mr. Parsons was introduced to the President by William Murray Black, Major General, U. S. A. (*Retired*), M. Am. Soc. C. E., and Professor Talbot was introduced by Past-President Charles F. Loweth.

Medals and prizes for papers were then awarded, as follows: Norman Medal to Harrison P. Eddy, M. Am. Soc. C. E.; the J. James R. Croes Medal to Charles S. Whitney, M. Am. Soc. C. E.; the Thomas Fitch Rowland Prize to H. de B. Parsons, M. Am. Soc. C. E.; the James Laurie Prize to William

Kelly, M. Am. Soc. C. E.; and the Arthur M. Wellington Prize to William Murray Black, M. Am. Soc. C. E.

Reports of the Alfred Noble Memorial Committee and of the Committee on Columbia University Scholarship* were submitted, following which several proposed amendments to the Constitution were presented for the consideration of the meeting. After discussion, amendments to Article II ("Membership") and Article III ("Admissions and Expulsions"), were adopted and ordered to letter-ballot. Three proposed amendments to Article VII ("Nomination and Election of Officers") were referred by majority vote to a Special Committee consisting of the eighteen Directors of the Society for report to the next general meeting of the Society.

The report of the Tellers† on the canvass of ballots for officers was presented and after a brief address, Retiring President Ridgway requested Past-Presidents Herschel and Pegram to escort the new President, George S. Davison, to the chair. Mr. Ridgway then presented President Davison to the meeting and Mr. Davison expressed his appreciation of the honor conferred on him.

After recess for luncheon, the meeting convened at 2:45 P. M., President Davison in the Chair, for the presentation of reports of Special Committees. The report of the Special Committee on Flood Protection Data,‡ was submitted by its Chairman, N. C. Grover, M. Am. Soc. C. E., and was discussed by Messrs. Morris Knowles and R. E. Horton. The Special Committee on Concrete and Reinforced Concrete Arches§ presented a progress report through its Chairman, Clyde T. Morris, M. Am. Soc. C. E. Before presenting the report, Professor Morris announced the death of John R. Chamberlin, M. Am. Soc. C. E., one of the members of the Committee, and read a memorandum relative thereto signed by the members of the Committee. The Special Committee on Stresses in Structural Steel‖ reported through F. O. Dufour, M. Am. Soc. C. E., Chairman, and the Minority Report was read by L. J. Towne, M. Am. Soc. C. E., a member of the Committee. The Committee asked to be discharged, and its request was granted by the Board of Direction at its meeting of January 21, 1926. The report of the Special Column Research¶ was submitted by F. E. Turneaure, M. Am. Soc. C. E., Chairman, and was followed by the presentation of the Final Report of the Special Committee on Impact in Highway Bridges,** A. H. Fuller, M. Am. Soc. C. E., Chairman, who illustrated his remarks with lantern slides. Thaddeus Merriman, M. Am. Soc. C. E., Chairman of the Special Committee on Cement,†† gave a brief abstract of the report of the Committee, and the subject was discussed by William W. Varney, M. Am. Soc. C. E. The next report, that of the Special Committee on Standard Construction Contracts,‡‡ was outlined by J. S.

* See Society Affairs, p. 87.
† *Proceedings*, Am. Soc. C. E., February, 1926, Society Affairs, p. 36.
‡ See Society Affairs, p. 134.
§ *Loc. cit.*, p. 136.
‖ See Papers and Discussions, p. 439.
¶ See Society Affairs, p. 146.
** See Papers and Discussions, p. 442.
†† See Society Affairs, p. 210.
‡‡ *Loc. cit.*, p. 223.

Langthorn, M. Am. Soc. C. E., Chairman, followed by discussion by Messrs. A. P. Greensfelder, J. C. Irwin, C. F. Allen, W. B. Bamford, T. L. Condron, and W. G. Atwood. In the absence of the Chairman, D. C. Henny, M. Am. Soc. C. E,, and other members of the Committee, the report of the Special Committee on Irrigation Hydraulics* was presented by Secretary Seabury. The Special Committee on Arbitration† through E. J. Mehren, M. Am. Soc. C. E., Chairman, reported briefly on the new arbitration laws adopted by a number of States and the Federal Government, and of their bearing on the work of engineers. The report of the Special Committee on Engineering Contract Bonding‡ was presented for the Committee by Frank C. Wight, M. Am. Soc. C. E. A brief progress report of the work of the Special Committee on Stresses in Railroad Track§ during 1925 was made by A. N. Talbot, Past-President and Hon. M. Am. Soc. C. E., Chairman, who stated that experimental tests had been made on the rail joint to determine the intensity and distribution of stresses in the splice-bar and in the rail at the joint, the characteristics of the flexural action for different forms of splice-bar, and the effect of varying conditions in the joint, such as position of bolts and fit of splice-bar to the rail. Robert A. Cummings, M. Am. Soc. C. E., Chairman, presented the progress report of the Special Committee on Bearing Value of Soils for Foundations, etc.,‖ and Secretary Seabury read the brief report submitted by J. D. Galloway, M. Am. Soc. C. E., Chairman, for the Special Committee on Effects of Earthquakes on Engineering Structures.¶ All these reports were received by the meeting and referred to the Board of Direction for action. After a few announcements relative to meetings, etc., the meeting was adjourned.

Meetings of the Board of Direction

These are abstracts of the notes of the Secretary and subject to approval by the Board of Direction at its next meeting.

Meetings of January 18 and 19, 1926.

The Board met at Society Headquarters on January 18 and 19, 1926, the following being in attendance: President Robert Ridgway, Secretary George T. Seabury; and, also, Messrs. Bowen, Braune, Brown, Bush, Chevalier, Condron, Davis, Dewell, Farnham, Fenkell, Gilman, Grunsky, Holmes, Howe, Humphrey, Ketchum, Loweth, Maitland, Mason, Merriman, Paul, Raymer, Spofford, Webster, Whitman, and Treasurer Hovey.

Annual Report of the Board of Direction:

The Annual Report** of the Board was approved and adopted.

* See Society Affairs, p. 242.
† *Loc. cit.*, p. 247.
‡ *Loc. cit.*, p. 259.
§ *Loc. cit.*, p. 256.
‖ This report will be published in a subsequent number of *Proceedings*.
¶ See Society Affairs, p. 257.
** *Loc. cit.*, p. 96.

Amendment to Article I, Section 1, of the By-Laws:

Article I, Section 1, of the By-Laws was amended by adding a sentence at the end of the first paragraph to read:

"An applicant for admission to the Junior grade of the Society who is a graduate of a school of engineering of recognized reputation shall furnish the names of at least two (instead of five) Corporate Members to whom he is personally known."

Article I, Section 1, as amended will read:

"1.—An application for admission to the Society or for transfer from one grade to another shall embody a concise statement, with dates, of the candidate's professional training and experience; and shall be in a form and in such detail as may be prescribed by the Board of Direction. It shall be signed by the applicant, and shall contain a promise to conform to the requirements of membership, if elected. The applicant shall furnish the names of at least five Corporate Members to whom he is personally known. Each of these shall be requested by the Secretary to address a letter to the Board of Direction, on a form prescribed by said Board, stating the extent of the writer's personal knowledge of the applicant and of his professional work. If at least five of the Corporate Members named as references do not furnish the requisite endorsement, the Secretary shall call upon the applicant for additional names, and not until written communications shall have been received from at least five Corporate Members shall the application be considered by the Board. An applicant for admission to the Junior grade of the Society who is a graduate of a school of engineering of recognized reputation shall furnish the names of at least two (instead of five) Corporate Members to whom he is personally known."

Amendment to Article II, Section 1, of the By-Laws:

Article II, Section 1, of the By-Laws was amended by changing the second sentence, as follows:

"A person elected after three months of any calendar year shall have expired, shall pay only the *pro rata* portion of the year's dues, reckoned from the first day of the month following the date of his notification of election."

and adding a third sentence, as follows:

"Members of the graduating class of a school of engineering of recognized standing who apply for admission not later than two months after graduation shall be exempt from the payment of the equivalent of one year's dues."

Article II, Section 1, as amended will read:

"1.—Dues shall be payable annually in advance on January 1. A person elected after three months of any calendar year shall have expired, shall pay only the *pro rata* portion of the year's dues, reckoned from the first day of the month following the date of his notification of election. Members of the graduating class of a school of engineering of recognized standing who apply for admission not later than two months after graduation shall be exempt from the payment of the equivalent of one year's dues. A person transferred from any grade to a higher grade shall pay the difference between the entrance fees of the two grades and his annual dues shall be those of the higher grade."

Surveying and Mapping Division of the Society Approved:

A petition with ninety-one signatures asking for the creation of a new Technical Division to be known as the Surveying and Mapping Division was presented and the organization of such Division was approved, the Executive Committee being given power to approve the Constitution when received in proper form.

Oklahoma Section Adopts Resolution of Appreciation to Director Howe:

A resolution adopted by the Oklahoma Section of the Society at its meeting on November 6, 1925, in appreciation of the services of Director Howe was presented to the Board, and the Secretary was authorized to notify the officers of the Section that the Board had received the communication with a great deal of pleasure.

Supplementary Progress Report of Committee on Aims and Activities:

The recommendations of the Supplementary Progress Report of the Committee on Aims and Activities, as published, in the February, 1926, *Proceedings*, page 41, were approved.

Report of Committee on Registration of Engineers:

The Committee on Registration of Engineers reported on the distribution of, and questions and comments on, its "Form of an Act of Legislation for Registration of Professional Engineers"* that was approved by the Board on January 20, 1925. The Committee was continued for the purpose of passing upon questions of procedure and to keep in touch with the adoption and administration of such laws in the various States.

Districts and Zones:

On motion, the Board decided that no change should be made at this time in the present Districts and Zones of the Society.

Meeting of the Incoming Board, January 21, 1926

The incoming Board of Direction met at 10:20 A. M. at Society Headquarters, on January 21, 1926, the following being in attendance: President George S. Davison; Secretary George T. Seabury; and, also, Messrs. Braune, Chevalier, Dewell, Farnham, Gilman, Grunsky, Hammond, Hatton, Hazen, Howe, Huber, Humphrey, Ketchum, Maitland, Merriman, Paul, Robert Ridgway, Sawyer, Taber, Webster, Williams, and Treasurer Hovey.

Standing Committees of the Board:

The following Standing Committees were appointed for 1926:

Executive Committee: George S. Davison, *Chairman,* Allen Hazen, *Vice-Chairman,* Willard T. Chevalier, Richard L. Humphrey, and Robert Ridgway.

* *Proceedings*, Am. Soc. C. E., March, 1925, Society Affairs, p. 75.

Committee on Technical Activities and Publications: Thaddeus Merriman, *Chairman*, Robert Farnham, Charles Gilman, Charles H. Paul, and Charles M. Spofford.

Public Relations Committee: Walter L. Huber, *Chairman*, Paul G. Brown, Alonzo J. Hammond, Alexander Maitland, Jr., and Frank M. Williams.

Committee on Local Sections: Henry D. Dewell, *Chairman*, J. M. Howe, and Donald H. Sawyer.

Committee on Professional Conduct: C. E. Grunsky, *Chairman*, Alonzo J. Hammond, and George S. Webster.

Committee on Student Chapters: Gustave M. Braune, *Chairman*, Albert R. Raymer, and Edward G. Taber.

Committee on Registration of Engineers: Robert Farnham, *Chairman*, T. Chalkley Hatton, J. M. Howe, Thaddeus Merriman, and Arthur O. Ridgway.

Committee on Research: Milo S. Ketchum, *Chairman*, C. B. Burdick, W. C. Cushing, A. T. Goldbeck, Anson Marston, F. E. Schmitt, Arthur N. Talbot, F. E. Turneaure, and Thomas H. Wiggin.

Committee on Honorary Membership: Robert Ridgway, *Chairman*, George S. Davison, C. E. Grunsky, Allen Hazen, Walter L. Huber, Richard L. Humphrey, Milo S. Ketchum, and George S. Webster.

Committee on Aims and Activities: Charles H. Paul, *Chairman*, Willard T. Chevalier, Henry D. Dewell, Donald H. Sawyer, and Charles M. Spofford.

1926 Annual Convention:

The date of the 1926 Convention of the Society was fixed for October 4 to 9, inclusive, in Philadelphia, Pa.

Budget for 1926:

The following proposed Budget for 1926, recommended by the outgoing Board to this Board for adoption, was approved:

INCOME

Item.	Estimated income for 1926.	
1 Entrance Fees	$17 250	
2 Dues	215 422	
3 Sale of Publications	5 500	
4 Binding of *Transactions*	8 400	
5 Sale of Badges	5 125	
6 Sale of Certificates	772	
7 Annual Meeting	5 000	
8 Interest on Bank Balance	1 300	
9 Interest on Securities	2 204	
10 From 57th Street Property	22 703	
11 Postage	150	
12 Miscellaneous (Service-Revolving Fund)	2 000	
13 Engineering Foundation	3 500	$289 326
Suggested Appropriations (See "Disbursements")		285 941
Unappropriated Balance		$3 385

DISBURSEMENTS

Item.		Appropriations for 1926.	
14	Salaries of Officers	$16 125	
15	Retirement Allowance	8 700	
16	Clerical Help	62 250	
17	Cost of Publications	68 000	
18	Binding of *Transactions*	6 000	
19	General Printing	5 330	
20	Badges	3 332	
21	Certificates of Membership	559	
22	Annual Prizes	380	
	Meetings:		
23	Annual Meeting	8 800	
24	Annual Convention (1926)	2 000	
25	Annual Spring Meeting	1 250	
26	Annual Summer Meeting	1 250	
27	Annual Fall Meeting	....	
28	Monthly Meetings	1 300	
29	Local Sections	8 000	
30	Student Chapters (Employment Bulletin)	1 100	
	Technical Divisions	4 500	
31	Sanitary	....	
32	Power	....	
33	Irrigation	....	
34	Highway	....	
35	City Planning	....	
36	Structural	....	
37	Waterways	....	
38	Construction	....	
39	Traveling Allowance of Officers	18 700	
40	Traveling Allowance of Standing Committees	1 700	
41	Work of Committees	15 300	
42	Reading Room	500	
43	Employment Service	1 815	
44	Office Supplies	4 000	
45	Postage	13 850	
46	Furniture and Office Equipment	2 500	
47	Current Business	3 875	
48	United Engineering Society:		
	General Assessment (Rent)	6 450	
	Library	8 000	
	Telephone	1 300	
	John Fritz Medal Board	175	
49	Interest on Mortgage	6 500	
50	Premium on Insurance	400	
51	Miscellaneous (Service-Revolving Fund)	2 000	$285 941

Meeting of City Planning Division

The first session of the Annual Meeting of the City Planning Division held at the Engineering Societies Building, New York, N. Y., on January 21, 1926, was called to order at 10:30 A. M., by Chairman Edwin A. Fisher. The Annual Report* of the Division was presented, and the election of the mem-

* See Society Affairs, p. 117.

bers of the new Executive Committee announced, as follows: Morris Knowles, *Chairman,* Charles B. Ball, *Secretary,* Harland Bartholomew, Frederic H. Fay, Charles W. Leavitt.

The meeting was a Joint Meeting of the Division with the American City Planning Institute, and Chairman Fisher introduced John Nolen, President, National Conference of City Planning, Cambridge, Mass., who addressed the meeting on "The Relation Between the Town Planner and the Engineer, Along the General Lines of Community Development", illustrating his remarks with lantern slides. Mr. Nolen was followed by Frederic H. Fay, M. Am. Soc. C. E., who presented an illustrated paper on "The Development of Mariemont, Ohio." Discussion on these subjects was opened by Thomas Adams, Director of Plants and Surveys, Regional Plan of New York and Its Environs, New York, N. Y., followed by Messrs. E. M. Bassett, Noulan Cauchon, and E. Wright Crawford.

The afternoon session was convened at 2:45 P. M., with Chairman Fisher presiding. Mr. Fisher introduced the new Chairman of the Division, Mr. Morris Knowles, and after taking the Chair, Mr. Knowles introduced President George S. Davison of the Society who addressed the meeting briefly. Secretary Seabury presented a letter from the Board of Direction addressed to all the Technical Divisions relative to the organization of the Committee on Technical Procedure.*

A paper by George B. Ford, Past-President, National Conference of City Planning and Vice-President, Technical Advisory Corporation, New York, N. Y., entitled "The City Plan of Cincinnati, Ohio", was presented by the author and discussed by Messrs. Bettman, Harland Bartholomew, Edwin A. Fisher, E. M. Bassett, Arthur C. Comey, L. J. Carmalt, E. P. Goodrich, T. T. Towles, and the author.

Construction Division Meeting

Morning and afternoon sessions of the Construction Division of the Society were held at the Hotel Pennsylvania, New York, N. Y., on Thursday, January 21, 1926.

The morning session which convened at 10:00 A. M., with A. P. Greensfelder, Assoc. M. Am. Soc. C. E., in the Chair, was the organization meeting of the Division. Charles S. Bilyeu, M. Am. Soc. C. E., was appointed Temporary Chairman and called on John F. O'Rourke, M. Am. Soc. C. E., who addressed the meeting briefly on the aims and objects of construction engineers. Mr. Greensfelder then read an "Outline of the Possibilities and Problems of the Construction Division", followed by discussion by Messrs. H. C. Turner, C. S. Hill, R. W. Atwater, J. A. Briggs, Arthur Hirst, and E. W. Bush.

The proposed Constitution of the Division was discussed and adopted and a Nominating Committtee was appointed to select the Executive Committee.

After recess for luncheon, the meeting convened at 2:00 P. M. The first business was the report of the Nominating Committee and the election of the Executive Committee, as follows: Messrs. William J. Barney, John P. H. Perry, A. C. Everham, A. S. Downey, and H. W. Latta.

* *Proceedings,* Am. Soc. C. E., February, 1926, Society Affairs, p. 40.

A paper entitled "Technical Problems in Construction Engineering" was presented by E. J. Mehren, M. Am. Soc. C. E., and was discussed by Messrs. P. S. Martin, E. W. Bush, and A. P. Greensfelder. A motion was adopted requesting the Executive Committee to recommend that the papers by Messrs. Greensfelder and Mehren be published in the *Proceedings* of the Society.

Following brief discussion of the activities of the Division, William Joshua Barney, Assoc. M. Am. Soc. C. E., presented an illustrated paper on "Modern Methods of Winter Weather Construction on Reinforced Concrete Buildings, with Some Observations on the Latest Field Methods in Designing Concrete Mixtures." James C. Meem, M. Am. Soc. C. E., read his paper entitled "Subway Construction Work in New York", also using lantern slides. The papers were briefly discussed by Messrs. O'Rourke and Greensfelder, and after votes of thanks to Mr. Greensfelder, the Board of Direction, the staff of the Society for assistance in preparing for the meeting, and to the speakers of the afternoon for their papers, the meeting was adjourned.

At a meeting of the Executive Committee following the Division meeting, William J. Barney was elected Chairman, John P. H. Perry, Vice-Chairman, and A. C. Everham, Secretary. Authority was given to prepare a program and make arrangements for a meeting of the Division at Kansas City, Mo., at the time of the Spring Meeting of the Society.

Highway Division Holds Meeting

Morning and afternoon sessions of the Annual Meeting of the Highway Division were held at the Engineering Societies Building, New York, N. Y., on January 21, 1926. The morning session was called to order with Secretary C. D. Curtiss presiding. After the reading of the Annual Report* of the Division by Mr. Curtiss, a paper by W. W. Crosby, M. Am. Soc. C. E., entitled "Economic and Engineering Problems of Highway Location", was read by Mr. E. E. Duff, Jr., and discussion on the subject was opened by Charles B. Breed, M. Am. Soc. C. E., followed by Messrs. Fred Lavis and H. C. Boyden. A paper by W. B. Catchings, State Construction Engineer, Raleigh, N. C., on "Bituminous Treatment of Earth Type Roads", was followed by discussion by Messrs. Prévost Hubbard and G. H. Henderson.

The afternoon session was addressed briefly by President George S. Davison of the Society, after which H. Eltinge Breed, M. Am. Soc. C. E., read his paper on "Recent Developments in Concrete Pavement Design", and a discussion of the subject by A. T. Goldbeck, Assoc. M. Am. Soc. C. E., was presented by R. W. Crum, M. Am. Soc. C. E. The paper was also discussed by Messrs. H. C. Boyden, E. G. Hooper, T. M. Ripley, E. E. Duff, Jr., A. L. Kurtz, G. H. Henderson, and C. R. Hulsart. Following the discussion, two motion pictures, "Wendover Cut-Off" and "Surf to Summit", were shown.

Power Division Meeting

The meeting of the Power Division was held at the Hotel Pennsylvania, New York, N. Y., on January 21, 1926, Mr. F. W. Scheidenhelm, presiding.

* See Society Affairs, p. 117.

An illustrated paper on "The Civil Engineering Features of the Kearney Power Station", was presented by Roman von Fabrice, Assoc. M. Am. Soc. C. E., following which, E. M. Van Norden, M. Am. Soc. C. E., presented a paper by George A. Hughes, M. Am. Soc. C. E., and himself, entitled "The Civil Engineering Features of the Hell Gate Power Station", illustrating his remarks with lantern slides. A general discussion of the papers followed in which Messrs. E. E. Halmos, R. W. Pommerer, G. A. Orrok, D. F. Holtman, and the authors took part. At the afternoon session, the Annual Report* of the Division for 1925 was read and the members of the Executive Committee for 1926 were announced as follows: Messrs. F. W. Scheidenhelm, *Chairman*, Arthur P. Davis, Daniel W. Mead, Nathan C. Grover, and I. W. McConnell. Following the business meeting, an illustrated paper by W. P. Creager, M. Am. Soc. C. E., entitled "The Soft Maple Dam of the Northern New York Utilities Company", was presented by the author and discussed by Messrs. Glenn D. Holmes, Joel D. Justin, E. W. Stern, J. J. Baker, N. C. Grover, E. H. Sargent, and Byron E. White. After a brief address by President George S. Davison, the meeting was adjourned.

Sanitary Engineering Division Meeting

Two sessions (morning and afternoon) of the meeting of the Sanitary Engineering Division were held at the Hotel Pennsylvania, New York, N. Y., on January 21, 1926, Chairman Langdon Pearse presiding.

The report† of the Committee on Filtering Material for Sewage and Water Work was presented by William E. Stanley, Chairman, and discussed by Harrison P. Eddy, M. Am. Soc. C. E. Chairman Pearse reported briefly on the Hering Medal,‡ stating that the Committee, having completed its work, had been discharged. The report§ of the Executive Committee was summarized, after which the newly elected Executive Committee of the Division was announced, as follows: Messrs. Samuel A. Greeley, John H. Gregory, Anson Marston, John C. Pritchard, and William L. Stevenson.

In opening the Symposium on Garbage Disposal, Mr. Greeley presented a "Review of the Problem", following which R. H. Gould, M. Am. Soc. C. E., read the paper on "Disposal by Hog Feeding: Michigan Practice", prepared by E. D. Rich, M. Am. Soc. C. E., showing lantern slides. A paper by Willis T. Knowlton, M. Am. Soc. C. E., on "California Practice of Disposal by Hog Feeding", was presented by John F. Skinner, M. Am. Soc. C. E. A paper by Arthur Boniface, Assoc. M. Am. Soc. C. E., on "Garbage Disposal by the Beccari System at Scarsdale, N. Y.", closed the Symposium.

A paper by James A. Burnett, Supervising Engineer, Department of Street Cleaning, Toronto, Ont., Canada, entitled "High Temperature Incineration at Toronto, Ont., Canada", was presented by the author, after which he showed a motion picture film illustrating how the garbage problem was handled in Toronto.

* See Society Affairs, p. 120.
† *Loc. cit.*, p. 128.
‡ *Proceedings*, Am. Soc. C. E., February, 1926, Society Affairs, p. 37.
§ See Society Affairs, p. 121.

Following a joint luncheon with the New York Section of the American Water Works Association, the meeting was called to order at 3:00 P. M., Mr. Pearse presiding. A paper by R. K. Davis, General Manager, Detroit Reduction Company, Detroit, Mich., entitled "Garbage Reduction at Detroit, Michigan", was presented by the author who also showed motion pictures of the work, and John V. Lewis, Superintendent of Waste Disposal, Rochester, N. Y., read a paper entitled "Cobwell System of Garbage Reduction and Some Phases of Its Operation at Rochester, N. Y.", illustrating his remarks with lantern slides.

A general discussion followed by Messrs. Harrison P. Eddy, Kenneth Allen, L. L. Tribus, and J. F. Jackson. Chairman Pearse then introduced President George S. Davison who addressed the meeting briefly.

ANNUAL DINNER OF SANITARY ENGINEERING DIVISION

About 60 members attended the Annual Dinner of the Division, which was held in the Hotel McAlpin, on Tuesday evening, January 19, 1926. The meeting was addressed by T. Chalkley Hatton, M. Am. Soc. C. E., who delivered an illustrated talk on the Activated Sludge Plant at Milwaukee, Wis.

Structural Division Holds Meeting

At the time of the Annual Meeting of the Society on January 21, 1926, the Structural Division held morning and afternoon sessions at the Engineering Societies Building, New York, N. Y., William G. Grove, presiding. The Annual Report* of the Division for 1925 was presented and the report of the Tellers on the election of the Executive Committee for 1926 was announced, as follows: Messrs. C. E. Chase, *Chairman*, William G. Grove, A. E. Lindau, F. E. Schmitt, and L. J. Towne. The business before the meeting was a letter from Secretary Seabury relative to proposed changes in Division Constitutions which was referred to the Executive Committee for action, and discussion on the meetings and programs of the Division.

A paper by D. B. Steinman, M. Am. Soc. C. E., entitled "The Design of the Florianopolis Suspension Bridge", was presented by the author, and Chairman Grove read a supplementary paper entitled "Construction of the Eye-Bar Cable Suspension Bridge at Florianopolis, Brazil", both of which were illustrated with lantern slides.

At the afternoon session Chairman Grove introduced Dudley F. Holtman, Assoc. M. Am. Soc. C. E., who presented a paper entitled, "The Engineer's Responsibility for Better Forest Utilization." After a brief address by President George S. Davison, the meeting was devoted to discussion on the papers on the Florianopolis Bridge by Messrs. L. S. Moisseiff, Spencer Miller, Frank W. Skinner, Jonathan Jones, and Shortridge Hardesty, and a discussion of the report of the Special Committee on Impact in Highway Bridges, by Messrs. F. O. Dufour, who used lantern slides to illustrate his remarks, L. M. Edwards, and A. H. Fuller.

* See Society Affairs, p. 124.

Meeting of Waterways Division

The Waterways Division met at the Hotel Pennsylvania, New York, N. Y., on January 21, 1926. After calling the meeting to order, Chairman John F. Coleman introduced John R. Slattery, M. Am. Soc. C. E., who presented a paper on "The Deeper Hudson". The paper was discussed by E. P. Goodrich, M. Am. Soc. C. E., who illustrated his remarks with lantern slides.

The count of the ballots for members of the Executive Committee resulted in the election of the following: Messrs. C. M. Spofford, M. G. Barnes, John F. Coleman, C. W. Kutz, and Harry Taylor. (General Taylor took the Chair.)

A paper by Royal G. Finch, M. Am. Soc. C. E., entitled "The Operation of the New York Barge Canal", was presented by the author, and discussed by Messrs. Frederic H. Fay (read by Mr. John Ayer), C. W. Kutz, M. W. Williams, Carleton Greene, T. Kennard Thomson, G. W. Kittredge, J. G. Basinger, E. P. Goodrich, W. G. Atwood, and Harry Taylor.

A communication from Secretary Seabury of the Society relative to the development of the activities of Technical Divisions was read and referred to the Executive Committee of the Division for action.

The afternoon was devoted to an excursion to rock-drilling operations and sea-going dredges in New York Harbor, made possible through the courtesy of the U. S. Engineer Department, First District, which furnished two boats for the trip. About 40 members went on this excursion.

February Society Meeting

The subject for discussion at the regular meeting of the Society held in the Engineering Societies Building, New York, N. Y., on February 3, 1926, was the paper on "Relation of Depth to Curvature of Channels", by Henry Clay Ripley, M. Am. Soc. C. E., published in the December, 1925 *Proceedings*. In the absence of Mr. Ripley, the paper was presented by Walter E. Spear, M. Am. Soc. C. E., and discussed by Messrs. O. H. Landreth, T. Kennard Thomson, George Paaswell, Leonard C. Jordan, T. H. Barnes, and J. L. Dobbins. A written discussion on the subject by E. G. Walker, M. Am. Soc. C. E., was read. The meeting was opened by President George S. Davison who called on Director Thaddeus Merriman to preside. Owing to the inclement weather, the attendance was only 32 and the meeting was adjourned about 9.15 P. M.

"Putting Across" the Certificate Plan

Everybody knew that it could be done—could be if (big "IF") only members would "play the game" together. But those who knew conditions best, who had seen the certificate plan of reduced railroad fares for the Society's Annual Meeting tried again and again only to fail because of apathy on the part of those who had little to gain—these were pessimistic. The inducement was always present, the attendance was more than sufficient, the loss to the engineer's pocketbook sufficiently appalling, but somehow the vital spark of co-operation, the will to help the other fellow, if not one's self, was not quite

strong enough. The Annual Meeting Committee with the strong advertising instinct conceived the idea that the proposition needed more publicity, so they circularized the nearer members, not once but twice—good "snappy" letters that stirred a man out of lethargy and impelled him to get a certificate as well as a ticket. When the smoke of the Annual Meeting had cleared the certificate plan was not a casualty; it had conquered by a good margin (313 obtained and only 250 needed) and the faith of the Committee was vindicated. Members attending the meeting from near and far had been saved an aggregate of about $2 000. Credit another victory to team work!

The records of these certificates show that they were distributed from Alabama on the south to Nebraska on the west and Canada on the north—surely a widespread benefit. The average distance was about 350 miles corresponding to a saving of almost $6.50. The economy actually effected is quite striking. For example, three members from Birmingham, Ala., saved about $55 altogether; sixteen from the vicinity of Chicago, Ill., benefited to the extent of $270; six from Iowa, Nebraska, and Missouri, $140; seven from Kentucky, Indiana, Ohio, and Michigan, $90; fourteen from Virginia and the District of Columbia, $85; eighty-one from Pennsylvania, $300; forty-six from New York State, $140; and fifty-four from New England, $200. As compared with the total amount spent for advertising (about $250), the results speak eloquently.

For the prize attendance, the palm goes to Boston (22), with Philadelphia (20) and Pittsburgh (19) not far behind. The Mohawk Valley and Lehigh Valley Districts were also strongly represented. Perhaps the greatest benefit from this experience, however, has been the encouragement that sheer accomplishment brings. That this success, although perhaps small financially, is still very real, cannot be denied. Best of all it helps those who most need help—the more distant members. Further, it will stimulate attendance in years to come when members can be assured of partial relief from the financial burden of railroad fares. Although the certificate plan was merely a minor feature of the Annual Meeting of 1926, its accomplishment bulks large in the minds of those intimate with its inherent difficulties. In quality if not in size it was one of the most satisfactory successes of the meeting.

Local Sections Award Prizes to Members of Student Chapters

The Society's Committee on Student Chapters is to be complimented on its work in arousing the interest of Local Sections in the Student Chapters. In its report to the Board of Direction on January 18, 1926, the Committee states that:

"During the past year your Committee has stressed to a considerable extent the co-operation between Student Chapters and Local Sections adopting a plan which has been approved by the Board, *viz.*, the granting by the Local Section of one or more prizes to members of Student Chapters, the prize in each case consisting of the entrance fee and first year's dues as Junior member in the Society."

These prizes are awarded for high scholastic standing and for papers on engineering subjects. The Sections that have made prizes available are, as follows:

Name of Local Section.	Number of Prizes.	University or College.
Central Ohio	1	Ohio State University
Cincinnati	1	University of Cincinnati
Detroit	1	University of Michigan
Georgia	1	Georgia School of Technology
	1	University of Georgia
Los Angeles	1	California Institute of Technology
Louisiana	3	Tulane University
New York	1	College of City of New York
	1	New York University
	1	Brooklyn Polytechnic Institute
	1	Rutgers College
	1	Cooper Union
North Carolina	1	(Not named)
Pittsburgh	1	University of Pittsburgh
	1	Carnegie School of Technology
Portland, Ore.	3	Oregon Agricultural College
St. Louis	1	Washington University
	1	University of Missouri
San Francisco	1	University of California
	1	Stanford University
Utah	1	University of Utah
	1	Utah Agricultural College
Western Washington	1	University of Washington
Lehigh Valley	1	Jointly between Lehigh University and Lafayette College
Central Illinois	1	University of Illinois

In addition to the sixteen Sections listed, which have arranged for twenty-nine prizes, thirteen and possibly more Sections have the matter under consideration.

New Committees Authorized

The following new committees were authorized by the Board of Direction at the Annual Meeting:

Standing Committee on Fees and Salaries

The purpose of this Committee, as stated in the recommendation of the Committee on Aims and Activities, is to investigate and report from time to time as to the prevailing rates of compensation throughout the profession and to make to the Board recommendations that seem desirable or pertinent.

The Committee is to consist of five members to be appointed by the President and is to be merged with a similar committee previously authorized. To co-operate with this Committee, the Local Sections are to provide Sub-Committees on Fees and Salaries.

Joint Committee on Stresses in Structural Steel

The appointment of a committee of five members was authorized to co-operate with a similar committee of the American Institute of Steel Con-

struction for the purpose of agreeing on specification covering allowable unit stresses and their application in the design of structural steel framework, especially for buildings.

Board of Direction Adopts Resolutions Relating to the Bonding of Engineers and to the Filling of Public Positions Requiring Engineering Training

At its meeting on January 19, 1926, the Board of Direction adopted resolutions relating to the practice of municipalities in bonding engineers for the performance of professional service and also on the filling of public positions requiring engineering training with qualified persons.

These resolutions, which were presented by the Committee on Public Relations are, as follows:

Resolution on Bonding of Engineers

"*Whereas:* It has come to the notice of the Board of Direction of the American Society of Civil Engineers that the giving of bonds to insure the faithful performance of professional services has, at various times and places in this country, been required of members of the Engineering Profession, more particularly by municipalities presumably under some general requirements that all contracts entered into by such municipalities must be fortified with the performance bond;

"*Whereas:* The dignity and the standing of the Engineering Profession would be lowered by a toleration of this practice which is out of harmony with the treatment of members of other Professions;

"*Therefore Be It Resolved:* That the American Society of Civil Engineers, through its Board of Direction, protests most vigorously against the placing of Professional Engineers under bond for the faithful rendering of professional service, and urges its members to make their propositions and agreements to render professional service in such form that wherever practicable bonding will be avoided."

Resolution Relating to the Filling of Public Positions Requiring Engineering Training with Qualified Persons

"*Whereas:* Persons untrained in technical matters are frequently appointed to fill public positions and offices whose incumbents should have knowledge and experience along engineering lines;

"*Whereas:* The practice is already well established in regard to other professions to recognize special qualifications, as, when a member of the Legal Profession is called upon to fill an office or position requiring a knowledge of law, or when a member of the Medical Profession is called to an office requiring medical training;

"*Therefore Be It Resolved* by the Board of Direction of the American Society of Civil Engineers, that public positions and offices whose incumbents are charged with duties requiring engineering or other technical training should be filled with properly qualified persons, and that whenever positions or offices are to be filled which are concerned with the administration of engineering matters, every reasonable effort should be made to fill the same with competent members of the Engineering Profession."

Report of Columbia Scholarship Committee

The Committee of the Society on the Scholarship of the Columbia School of Mines, Engineering, and Chemistry—a Graduate Scholarship made available

to the Society by Columbia University for the last four college years, amounting to $350, or substantially the tuition—reported to the Annual Meeting on January 20, 1926, that during the past year, a single application was received from a student of the University of Maine and was approved by the Committee. The applicant, however, changed his plans, and the Society has thus far failed to avail itself of the Scholarship. For the coming year, one application has been received from a student of the University of Pennsylvania, and it is hoped that there may be others.

The Committee recommended:

First.—That in the spring, appropriate notice again be given in the *Proceedings* of the Society.

Second.—That a special notice be sent to each Local Section requesting that effort be made to secure suitable candidates.

Third.—That the New York Local Section, in view of a probably greater local interest in a New York Scholarship, be urged to make especial effort in the matter.

Fourth.—That a special notice be sent to each Student Chapter.

Two New Student Chapters Authorized

In accordance with the recommendations of the Committee on Student Chapters, the Board of Direction on January 18, 1926, authorized Student Chapters to be organized at the University of Arkansas, Fayetteville, Ark., and at Union College, Schenectady, N. Y.

This makes a total of 79 Student Chapters organized or authorized, aggregating in membership approximately 4 300.

Tour of Alaska and Pacific Northwest in Connection with Seattle Meeting

A wonderful tour has been arranged in connection with the Summer Meeting in Seattle next July. The entire trip, including the meeting, will occupy five weeks, and will include visits to Glacier and Rainier National Parks; Seattle and other Puget Sound points; Victoria and Vancouver, British Columbia; Alaska; Jasper National Park; Lake Louise; and Banff.

Stops will be made at Glacier and Rainier National Parks prior to the meeting, on the way to Seattle. Immediately on the close of the meeting, the party will visit Victoria and Vancouver, British Columbia, and, thence, *via* Canadian National steamship, to Skagway, stopping at Ocean Falls, Prince Rupert, Ketchikan, Wrangell, and Juneau. From Skagway an excursion will be made to West Taku Arm over the White Pass and Yukon Route.

The return journey will be by boat to Prince Rupert, thence by rail to Jasper National Park, Lake Louise, and Banff, and, finally, to Chicago and points east.

Complete details of this tour are not entirely worked out, but inquiries will be welcomed in advance of the final itinerary, which will give full information regarding cost, time, schedules, etc., to be published later, either in the *Proceedings*, or by separate folder.

Kansas City Engineers Arrange Radio Educational Program

Belief that the general public will be interested in engineering talks *via* radio is shown by the program arranged by R. E. McDonnell, M. Am. Soc. C. E., for the Engineers Club of Kansas City, to be broadcast from Station WDAF. This program, which was arranged through the *Kansas City Star,* will consist of a series of 10-in. lectures on engineering subjects by experts in their particular lines, to be given every Saturday at 6:00 P. M. Comments about this program should be transmitted to the *Kansas City Star,* WDAF, Kansas City, Mo.

The tentative schedule of topics, speakers, and dates is, as follows:

1.—Electrical Engineering, by R. L. Baldwin........................March 6
2.—Military Engineering, by E. M. Stayton, M. Am. Soc. C. E., City Member, Board of Control, Kansas City Railways............March 13
3.—Power Plant Engineering, by A. E. Bettis, of the Kansas City Power and Light Company..March 20
4.—City Planning and Zoning, by Charles E. Donnelly, Assoc. M. Am. Soc. C. E., Engineer, City Plan Commission, Kansas City. March 27
5.—Architectural Engineering, by Ernest O. Brostrom..............April 3
6.—Surveying, Mapping and Sub-Divisions, by Frank W. Tuttle, of Tuttle, Ayres and Woodward..................................April 10
7.—Railroad and Terminal Engineering, by John V. Hanna, M. Am. Soc. C. E., of Kansas City Terminal Railway Company......April 17
8.—City or Municipal Engineering, by Paul McGeehan, M. Am. Soc. C. E., City Engineer, Kansas City..............................April 24

John Fritz Medal Awarded to Edward Dean Adams

The John Fritz Medal Board awarded on January 15, 1926, its Gold Medal, the highest honor bestowed by American engineers, to Edward Dean Adams for achievement as "an Engineer, Financier, Scientist, whose vision, courage and industry made possible the birth at Niagara Falls of hydro-electric power." The presentation will be made on March 30, 1926, in the Auditorium of Engineering Societies Building, New York, N. Y.

Mr. Adams was born in Boston, Mass., in 1846, and was graduated as a Bachelor of Science from Norwich University in 1864, afterward pursuing engineering studies at the Massachusetts Institute of Technology. He was elected a Fellow of the Society in 1891, and an Associate of the American Institute of Electrical Engineers in 1910. Mr. Adams has served as Vice-Chairman of Engineering Foundation from its beginning, and for years was an active member and officer of Engineering Societies Library.

It was on his decision that alternating current was chosen for the epoch-making plant of the Niagara Falls Power Company in 1891 and for the transmission of the power by wire to Buffalo, N. Y. He made extensive studies of the latest forms of electric generators and water turbines in Europe and America. He adhered to his momentous decision on the kind of electric current and equipment to be used in spite of contrary opinions emphatically expressed by Thomas A. Edison and Sir William Thomson.

Mr. Adams has been a patron of expeditions for observing total eclipses of the sun and of other scientific investigations and has personally participated

in some of them. He is a member of National Research Council and of the American Museum of Natural History. He has also been a patron of the fine arts in the United States and other countries and for many years a Trustee of the Metropolitan Museum of Art.

Most of his long and intensely active business life was devoted to large enterprises combining engineering and finance. He had a leading part in the organization and re-organization of numerous railroads, including the West Shore, the Central of New Jersey, the Western Maryland, and the Northern Pacific. He created the American Cotton Oil Company out of innumerable small companies; led in establishing the All-America Cables; and had an important share in many other industrial undertakings. For fifteen years he was a member of the banking firm of Winslow, Lanier, and Company, and for twenty-one years American representative of the Deutsche Bank of Berlin.

A host of friends, men of national and international reputation in many fields, entertained Mr. Adams at a dinner at the Waldorf-Astoria Hotel, New York, N. Y., on April 9, 1925, in celebration of his seventy-ninth birthday.

The Medal has heretofore been conferred upon the following engineers:

John Fritz	Elihu Thomson
Lord Kelvin	Henry Marion Howe
George Westinghouse	J. Waldo Smith
Alexander Graham Bell	George W. Goethals
Thomas Alva Edison	Orville Wright
Charles T. Porter	Sir Robert Hadfield
Alfred Noble	Charles Prosper Eugene Schneider
Sir William Henry White	Senator Guglielmo Marconi
Robert W. Hunt	Ambrose Swasey
John Edson Sweet	John F. Stevens
James Douglas	

Strathcona Memorial Fellowships in Transportation

Five Strathcona Memorial Fellowships in Transportation, of $1 000 each, are offered by the Graduate School of Yale University annually for advanced work in Transportation, with special reference to the construction, equipment, and operation of railroads, and other engineering problems connected with the efficient transportation of passengers and freight, as well as the financial and legislative questions involved. Transportation by water, highways, or airways, and the appropriate apparatus involved, and also other general aspects of the broad field of transportation, embracing its legal and economic phases, will be included in the list of subjects which the Fellows may select for investigation and study. The holder of a Fellowship must be a man who has obtained his first degree from an institution of high standing. In making the award, preference is given, in accordance with the will of Lord Strathcona, to such persons or to the sons of such persons as have been, for at least two years, connected in some manner with the railways of the Northwest.

Applications for these Fellowships should be addressed to the Dean of the Graduate School of Yale University, New Haven, Conn., before April 1,

on blanks which may be obtained from him. Applicants must submit with their application a brief biography, and a certified record of their previous courses of study in college or technical school, and their standing therein. They should also submit testimonials bearing upon their qualifications. A recent photograph of the applicant is requested.

Various courses of study relating to transportation along engineering, economic, and legal lines are now offered by Yale University. For further details the applicant is referred to the Catalogue of the Yale University Graduate School. Upon completion of the pending survey of various fields of Transportation and the character of instruction and investigation therein, there may be anticipated some re-arrangement of certain of the courses cited and some amplification thereof. Pending such adjustment, the Strathcona Memorial Fellows will be entitled to pursue investigation in those aspects of Transportation in which the University now offers competent guidance and supervision.

Financial Report of United Engineering Society

The following summary from the report of the Treasurer of United Engineering Society for 1925 is presented. United Engineering Society has charge of Engineering Societies Building, Engineering Societies Library, and other engineering interests.

Operation of Building

Credit balance January 1, 1925		$4 804.64
Revenue from prior years		0.00
Building revenue, 1925	$117 422.17	
Building expenditures, 1925	100 255.80	17 166.37
		$21 971.01
Annual payment to Depreciation and Renewal Fund	$12 000.00	
Additional payment to Depreciation and Renewal Fund	1 305.60	
Miscellaneous adjustments	24.38	13 329.98
Credit balance, December 31, 1925		$8 641.03

Operation of Library

Maintenance revenue	$41 176.89	
Maintenance expenditures	41 176.89	
Balance, December 31, 1925		$0.00
Service Bureau revenue	$14 615.99	
Service Bureau expenditures and adjustments	15 157.86	
Operating deficit and adjustments		$541.87
Credit Balance, December 31, 1924		1 398.12
Credit Balance, December 31, 1925		$856.25

Funds and Property

Funds held by United Engineering Society, December 31, 1925 (Book Value):		
Depreciation and Renewal		$192 623.70
Engineering Foundation		479 542.97
Henry R. Towne Engineering Fund		49 953.13
Library Endowment		97 506.37
Reserve for Depreciation of Capital of Library		4 000.00
General Reserve		10 000 00
John Fritz Medal (U. E. S., Custodian)		3 500.00
Total		$837 126.17
Real Estate owned by U. E. S., cost to December 31, 1925		$1 966 569.44
Operating cash and petty cash		8 310.38
Accounts receivable		4 389.45
Value of Library (as appraised for insurance)		329 000.00
Total property for which U. E. S. is Trustee or Custodian		$3 145 395.44

BALANCE SHEET

Assets

Real Estate:		
Land	$540 000.00	
Building	1 369 398.28	
Equipment	33 171.16	
Founders' preliminary expenses	24 000.00	$1 966 569.44
Investments and Cash Uninvested:		
Depreciation and Renewal Fund		$192 623.70
Engineering Foundation Fund		479 542.97
Library Endowment Fund		97 506.37
General Reserve Fund		10 000.00
Reserve for Depreciation of Library capital		4 000.00
Henry R. Towne Engineering Fund		49 953.13
Operating cash and petty cash		8 310.38
Accounts receivable		4 389.45
		$2 812 895.44

Liabilities

Founders' equity in property	$1 966 569.44
Depreciation and Renewal Fund	192 623.70
Engineering Foundation Fund	479 542.97
Library Endowment Fund	97 506.37
General Reserve Fund	10 000.00
Reserve for Depreciation of Library capital	4 000.00
Henry R. Towne Engineering Fund	49 953.13
Deposits on account hall rentals	35.00
Credit balance in Accounts Receivable	101.68
Deferred credit—Miscellaneous Contributions to Library	3 065.87
Credit balance in activity accounts	9 497.28
	$2 812 895.44

The Engineer as City Commissioner

The recent vote in Dayton, Ohio, resulted in the election of Charles H. Paul, a Director of the Society, as a member of the City Commission. This Board has five members; the three just elected ran on a non-partisan citizens ticket. Mr. Paul is the first engineer to hold membership on the City Commission since it was created in 1914. This increasingly popular form of government provides an admirable medium for the business man and the engineer to serve the public. The Dayton election is only one example of the important contributions being made by engineers to local civic affairs. In proportion to its willingness to serve the public will be the public's appreciation of the profession. This type of activity is one of the most effective, most distinctive, and most valuable that the engineer can render to his fellow men.

A Second Volume of Research Narratives

Engineering Foundation has just collected the second fifty of its Research Narratives and issued them in a book better bound and a little larger than the first volume. The new book is illustrated with five portraits of engineer-scientists and has an Introduction by Professor M. I. Pupin, Past-President, American Institute of Electrical Engineers and American Association for the Advancement of Science. The price is one dollar, postpaid. The first volume is still obtainable at a cost of fifty cents per copy. These brief stories of research, invention, and discovery have been well received, widely copied, and utilized in many ways. They have carried the gospel of science coupled with the names of the American Societies of Civil, Mining and Metallurgical, Mechanical, and Electrical Engineers into most of the countries of the world. Requests and remittances should be sent to Engineering Foundation, at 29 West 39th Street, New York, N. Y.

Local Sections*

Colorado.—December 14, 1925. A dinner was held at the Metropole Hotel, Denver, at which Professor J. A. Jeancon, Curator of Archæology of the State Historical Museum, was a guest. Professor Jeancon gave an illustrated talk on discoveries relating to prehistoric Colorado. Mr. John L. Savage read a comprehensive abstract of the minutes of the Local Sections' Conference at the Annual Convention of the Society at Cincinnati, Ohio. Committee reports were received and other business matters transacted. Attendance 24.

January 12, 1926. After a dinner at the Elks Club, Denver, the 151st meeting of the Section was held. Dr. George B. Vosburg, the guest of the evening, delivered a lecture on "The World To-Day", in which he briefly outlined the development of the fine arts and science from the days of the splendor of Athens to the Twentieth Century. Several Committee reports were read. Attendance 26.

District of Columbia.—January 9, 1926. Annual Meeting. The following officers were elected: President, George A. Ricker; Vice-President, C. Dwight Avery; Secretary-Treasurer, Edwin H. Pagenhart. These officers, with Messrs. A. N. Johnson and James H. Van Wagenen, compose the Board of Directors.

Iowa.—January 26, 1926. This meeting was held at Mason City, with the following program: "The Manufacture of Portland Cement", by G. C. Blackmore, Chief Chemist, Northwestern States Portland Cement Company, Mason City; "The Testing of Portland Cement", by B. L. Bowling, Laboratory Chief, Iowa State Highway Commission; and "What is Good Concrete?" by B. J. Lambert, Head, Department of Civil Engineering, State University of Iowa. Attendance 36.

Portland (Ore.).—November 20, 1925. Mr. R. F. Hoffmark presented a paper describing construction methods used in the building of the Lake Cushman Dam for the City of Tacoma, Wash. Attendance 22.

Sacramento.—January 5, 1926. At a joint meeting of the Section with the Sacramento Chapter of the American Association of Engineers, Judge Peter J. Shields of the Sacramento County Superior Court delivered an address on "Abraham Lincoln". Attendance 35.

January 12, 1926. This was the Fourth Annual Meeting of the Section and the following officers were elected for 1926: President, Everett N. Bryan; First Vice-President, J. Burdette Brown; Second Vice-President, Royal U. St. John; Secretary, Norwood Silsbee. The Secretary's report for 1925 showed a membership of 54, a gain of 13 over 1924, and an average attendance at the weekly luncheons of 28. The library of the Section contains 326 publications. It was started two years ago and during the year has increased 100 per cent.

January 19, 1926. Retiring President J. C. Boyd delivered his Annual Report. The Annual Report of the Sacramento Ship Canal Committee, which states that such a canal is unnecessary in the near future, was adopted by the Section. Attendance 28.

* For list of Local Section Officers, Rules, etc., see 1925 Year Book, p. 48.

January 22, 1926. The annual dinner and dance of the Section was given at the Hotel Sacramento and the officers for 1926 were installed. Retiring President J. C. Boyd delivered an address on "The Sphere of the Engineer", and the new President, Mr. Everett N. Bryan, spoke on "Service". Past-President Edward Hyatt, Jr., in behalf of the Section, presented Mr. Boyd with the gavel he had used during the past year, suitably engraved. Past-Presidents C. S. Pope and Albert Givan were also speakers. Attendance 61.

January 26, 1926. Albert Givan, General Manager and Chief Engineer of Sacramento Municipal Utility District, read a paper on the proposed development of the American River at Folsom, where it is planned to erect a masonry dam to store approximately 300 000 acre-ft. of flood water and eliminate the flood menace in winter. Electric power would be generated as a by-product, and the stored water would be largely used for summer irrigation.

Spokane.—December 11, 1925. Annual Meeting. The following officers were elected: President Charles E. Davis; First Vice-President, John C. Fowler; Second Vice-President, Homer C. Bender; Secretary-Treasurer, W. L. Morgan. The proposed Engineers License Bill for the State of Washington was discussed, and a motion to lay it on the table was carried. The matter of offering Junior Memberships in the Society, as prizes to Senior engineering students, was carefully considered but no definite action was taken.

Texas.—November 13-14, 1925. Fall Meeting, Fort Worth, Tex. The following officers were elected: President, J. C. McVea; First Vice-President, F. E. Giesecke; Second Vice-President, C. T. Bartlett; Secretary-Treasurer, E. N. Noyes; Directors, J. A. Norris and A. J. McKenzie. Papers by Mr. E. H. Flath on "The Co-operative Plan of Technical Education at Southern Methodist University" and by Mr. O. H. Koch on "City Planning as It Affects Highways" were particularly interesting and were discussed at length. Mr. J. H. Brillhart led in a discussion on "A National Department of Public Works". A luncheon was served at the plant of the TrinityPortland Cement Company to those attending the meeting.

Western Washington.—January 25, 1926. The following officers were elected: W. J. Barden, President; Thomas R. Beeman, Vice-President; E. L. Strandberg, Secretary-Treasurer. The past year has been the most active, technically, in the history of the Section. Ten meetings and one excursion were held with an average attendance in excess of 50% of the membership. All the papers presented have been by local engineers on local engineering subjects.

Annual Reports

ANNUAL REPORT OF THE BOARD OF DIRECTION FOR THE YEAR ENDING DECEMBER 31, 1925

In compliance with the Constitution, the Board of Direction presents its Report for the year ending December 31, 1925.

THE SEVENTY-THIRD YEAR

The following matters of which the membership has been notified are given briefly, after which the standard activities of the Society are noted in greater detail.

Death of Director Norcross

Paul H. Norcross, Director of the Society, died May 8, 1925, in the *Norman* disaster.

Norman Disaster

The Board records its profound regret at the death of a number of prominent members of the Society, including Director Norcross, through the disaster on the Mississippi River, at the time of the sinking of the Steamer *Norman*. Twelve members lost their lives, and in addition four members of their families were also lost. Seldom has the Society been thus afflicted by a single catastrophe.

Aims and Activities Committee

Perhaps the one outstanding feature of the year which gives evidence of having lasting and far-reaching effect upon the conduct of the Society is the appointment and work of the Aims and Activities Committee. This Committee, composed of five members of the Board, was appointed "to study the Society, its aims and activities, and to present a constructive outline of desirable and practical ways and methods of advancing the Society", and to report its findings to the Board for such action as the Board might find practicable. The Committee presented to the October Board meeting a progress report in which were 24 definite recommendations relating to Society membership qualifications, and other details; to the furthering of the work of the Technical Divisions; to the publications of the Society; and to matters having to do with professional practice.

Of these recommendations nineteen were approved by the Board of Direction and have already been put into effect or are in process of development, and five were referred to other committees of the Board for consideration and further report and may be expected to be put into operation shortly, though possibly in modified form.

It is felt that when consummated, those recommendations having to do with the Technical Divisions will result in placing upon the Divisions the responsibility for stimulating and guiding the technical activities of the Society and will insure systematic and well-balanced work by the Society in the various branches of Civil Engineering.

Technical Divisions

This year has seen the further development of the Technical Division. The Waterways Division was organized at the Annual Convention in Cincinnati, Ohio, and the Construction Division will be organized at the 1926 Annual Meeting.

There are now eight Divisions, organized or authorized, with a total membership of 5 617.

Local Sections Conference

A Local Sections Conference was held on April 21, 1925, at the Annual Convention in Cincinnati, twenty-eight Sections being represented. The Program of the Conference was arranged by the Committee on Local Sections and covered three main topics as follows:

1.—Methods of co-ordinating work and interest of Local Sections with work and interest of National Society.

2.—Local Section activities.

3.—Open forum for discussion of National Society affairs.

An afternoon and evening was devoted to the discussion of these topics by the Section representatives and members of the Board of Direction.

Local Membership Committees

During the last two years, Local Membership Committees have greatly assisted the Board in the consideration of applicants for admission and transfer. In the various Districts, there are now 53 of these Committees with 174 members, which form effective agencies for the scrutiny of the qualifications of applicants.

Prizes to Student Chapters

Following the example of the Portland Local Section and at the suggestion of the Committee on Student Chapters, several of the Local Sections have authorized the granting, to one or more students of the graduating class affiliated with Student Chapters of the Society, prizes to consist of the initiation fee and the equivalent of the first year's dues for Junior Membership in the Society. This development has already become a valuable stimulus to the Society through the enlistment of the interest of the most desirable type of young engineer.

MEETINGS OF THE BOARD OF DIRECTION

There have been seven meetings of the Board of Direction during 1925:

January 19-20, New York, N. Y.
January 22, New York, N. Y.
March 16, New York, N. Y.
April 20-21, Cincinnati, Ohio
July 6-7, Salt Lake City, Utah
October 12-13, Montreal, Que., Canada
December 14, New York, N. Y.

There have been four meetings of the Executive Committee held in New York during 1925, as follows: March 16, June 3, September 14, and December 14.

MEMBERSHIP

The changes in membership are shown in the following table:

	JAN. 1, 1925.			JAN. 1, 1926.			LOSSES.				ADDITIONS.		TOTALS.		
	Resident.**	Non-Resident.	Total.	Resident.**	Non-Resident.	Total.	Transfer.	Resignation.	Dropped.	Died.	Transfer.	Election.	Loss.	Gain.	Increase.
Honorary Members	3	10	13	4	11	15	0	0	0	0	2	0	0	2	2
Members	878	4 057	4 935	872	4 173	5 045	2	22	101	81	*156	‡160	206	316	110
Associate Members	862	4 458	5 320	859	4 383	5 242	152	43	326	20	†48	§415	541	463	¶78
Juniors	175	561	736	180	641	821	47	15	59	1	.....	‖207	122	207	85
Affiliates	59	99	158	52	98	150	5	4	9	3	.....	‖13	21	13	¶8
Fellows	4	4	8	4	4	8	.....	.....	.....	...	.....	.....	.....	.....	...
Total	1 981	9 189	11 170	1 971	9 310	11 281	206	84	495	105	206	795	890	1 001	111

* 152 Associate Members and 4 Affiliates.
† 47 Juniors and 1 Affiliate.
‡ 25 Reinstatements.
§ 55 Reinstatements.
‖ 1 Reinstatement.
¶ Decrease.
** Those residing within fifty miles of the City Hall, New York, N. Y.

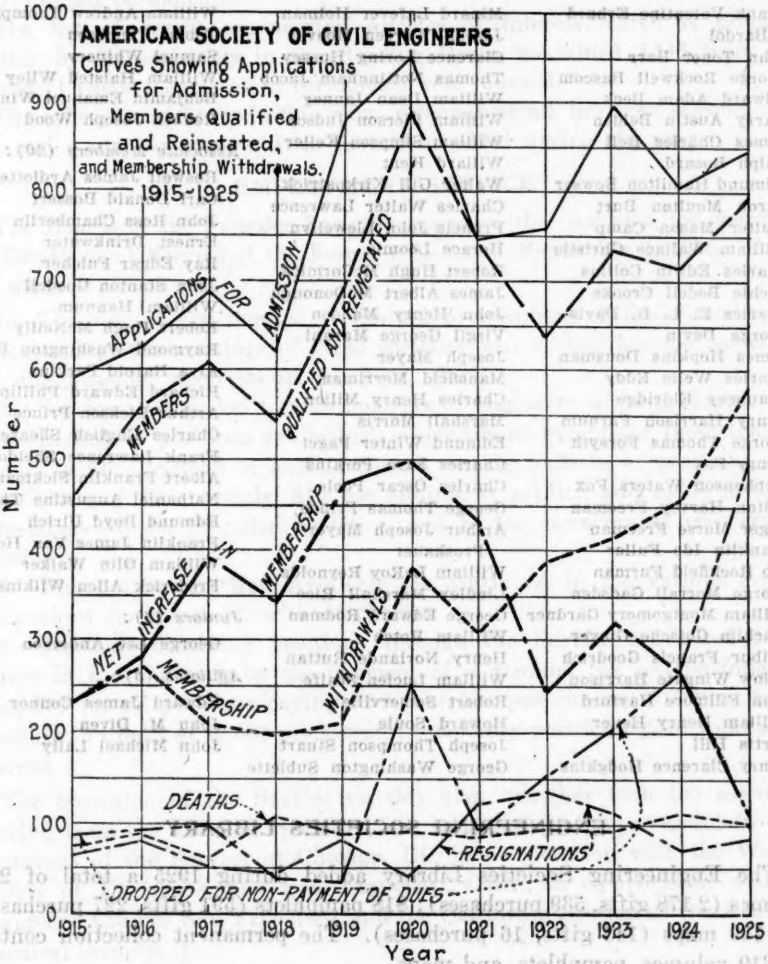
New Members and Net Increase

The following table shows the new members and the net increase during the past ten years. The accompanying diagram gives membership statistics for the same period.

	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925
New Members*	552	608	537	687	887	743	636	733	715	795
Net increase	283	398	343	475	499	435	246	320	262	111

* Includes reinstatements.

The net increase it will be noted shows a marked falling off from previous years. This is attributable for the most part to the dropping of those members who have been in arrears of dues. It is felt that the condition of the Society with respect to membership is healthier than it has been for a number of years.



CURVES SHOWING NEW MEMBERS AND NET INCREASE IN MEMBERSHIP, 1914-1925.

Applications for Membership

The total number of applications for membership was 1 104, of which 848 were for admission and 256 for transfer.

Deaths

The losses by death during the year number 105 and are as follows:

Past-Presidents and Present Officers (2):

Past-President: George Henry Benzenberg.

Director: Paul Howes Norcross.

Members (79):

Ira Osborn Baker
Frank Valentine Erhard Bardol
John Toner Barr
George Rockwell Bascom
Edward Adam Beck
Harry Austin Belden
James Charles Bell
Ralph Bosard
Edmund Hamilton Bowser
Aaron Moulton Burt
Walter Mason Camp
William Wallace Christie
Charles Edwin Collins
Archie Bedell Crooks
Charles E. L. B. Davis
George Devin
James Hopkins Dousman
Charles Wells Eddy
Chauncey Eldridge
Henry Harrison Farnum
George Thomas Forsyth
Henry Fox
Stephenson Waters Fox
Milton Harvey Freeman
Roger Morse Freeman
Franklin Ide Fuller
Job Rockfield Furman
George Morrall Gadsden
William Montgomery Gardner
Joachim Gotsche Giaver
Wilbur Francis Goodrich
Edlow Wingate Harrison
John Fillmore Hayford
William Henry Heuer
Curtis Hill
Henry Clarence Hodgkins
Olaf Hoff
Minard Lafever Holman
Joseph Warren Hoover
Clarence Loring Hussey
Thomas Nottingham Jacob
William Dean Janney
William Pierson Judson
William Simpson Keller
Willard Kent
Walter Gill Kirkpatrick
Charles Walter Lawrence
Francis John Llewellyn
Horace Loomis
Robert Hugh McCormick
James Albert McDonough
John Henry Madden
Virgil George Marani
Joseph Mayer
Mansfield Merriman
Charles Henry Miller
Marshall Morris
Edmund Winter Paget
Charles Ezra Perkins
Charles Oscar Poole
George Thomas Prince
Arthur Joseph Mayer Proskauer
William LeRoy Reynolds
Lindley Marshall Rice
George Edward Rodman
William Rotch
Henry Norlande Ruttan
William Lucien Scaife
Robert Somerville
Howard Soule
Joseph Thompson Stuart
George Washington Sublette
Judson Gilman Tabler
William Andrew Thompson
Tobias Tönnesen
Samuel Whinery
William Halsted Wiley
Benjamin Emanuel Winslow
Reuben Joseph Wood

Associate Members (20):

Roswell James Aydlotte
Carl Donald Bossert
John Ross Chamberlin
Ernest Drinkwater
Ray Edgar Fulcher
John Stanton Goodell
William Hannum
Robert Hugh McNeilly
Raymond Washington Parlin
Alva Harold Perkins
Richard Edward Phillips
Arthur Dickson Prince
Charles English Shearer
Frank Lawrence Sheldon
Albert Franklin Sickman
Nathaniel Augustine Thayer
Edmund Boyd Ulrich
Franklin James Van Hook
William Olin Walker
Frederick Allen Wilkinson

Juniors (1):

George Lee Anderson

Affiliates (3):

Edward James Connor
John M. Diven
John Michael Laily

ENGINEERING SOCIETIES LIBRARY

The Engineering Societies Library added during 1925 a total of 2 717 volumes (2 178 gifts, 539 purchases); 818 pamphlets (591 gifts, 227 purchases); and 159 maps (143 gifts, 16 purchases). The permanent collection contains 110 319 volumes, pamphlets, and maps.

Expenditures for books, periodicals, binding, supplies, and salaries were approximately \$41 000. The Library was used by 35 511 persons, 25 354 of whom visited it.

During the year, 7 747 volumes were catalogued and 32 003 cards added to the catalog. This catalog now contains 263 931 cards, arranged under subjects. The Search Department attended to 334 inquiries, making 238 searches and 96 translations, totaling 191 930 words. The Photoprint Department

made 27 373 photoprints for 2 666 persons. The receipts for these services, approximately $14 000, covered the cost.

Books were lent to 204 distant members.

READING ROOM OF THE SOCIETY

The attendance at the Reading Room during the year was 2 308.

A total of 290 periodicals are regularly received, and this number covers many foreign periodicals.

The list of recent engineering articles of interest which is prepared monthly by the assistants in the Reading Room, contained 2 145 titles and covered 71 pages. Forty-eight periodicals were indexed.

The collection of books in this room, although small, has been selected with care, and a number of new titles have been added during the year.

EMPLOYMENT SERVICE

The Boards of the Founder Societies approved the new plan for operating the Employment Service of the Founder Societies, September 1, 1923. Under this plan:

1.—The use of the Service is limited to members of the Founder Societies, and to the members of those societies which shall become associated with the Founder Societies in the joint effort.

2.—Service is extended to all employers of engineers without charge.

3.—Listing of positions available is discontinued except for those that are difficult to fill. Instead of such listing, a weekly bulletin of positions, at a subscription of $3 quarterly, $10 per annum, is printed and made available to members of the Founder Societies, and to the members of co-operating societies.

4.—Publication of "Men Available" is continued in the various Society publications for members, without charge.

5.—Members obtaining positions through the Service are asked to co-operate in the financing by the payment of a nominal fee, on the following basis, $10 for all positions paying $2 000 or less per annum; $10 plus 1% of all salary in excess of $2 000 per annum; temporary position 3% of total salary received.

The operation of the Service on this plan, together with the assistance received from the Founder Societies, has been sufficiently successful to make extensions of the Service in Chicago, Ill., in co-operation with the Western Society of Engineers, and San Francisco, Calif., in co-operation with the Engineers' Club of San Francisco, and the California Section of the American Chemical Society.

The extension of the Service to large cities other than New York is in pursuance of the recommendations adopted by the Boards of the Founder Societies.

The number of men placed during 1925 has averaged about 75 per month, and is as follows:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
Men registered....	129	101	134	130	148	140	101	86	102	109	62	81	1 323
Men placed.......	36	67	88	60	64	91	103	64	94	75	70	86	898

COMMITTEES

The seventeen Special Committees authorized to report on engineering subjects are as follows:

To Codify Present Practice on the Bearing Value of Soils for Foundations (Authorized December 3, 1912).
Stresses in Railroad Track (Authorized November 12, 1913).
To Consider and Recommend for Adoption a Specification for Bridge Design and Construction (Authorized August 9, 1920).
Standard Construction Contracts (Authorized June 6, 1921).
Electrification of Steam Railways (Authorized January 16, 1922).
Impact in Highway Bridges (Authorized April 4, 1922).
Stresses in Structural Steel (Authorized April 4, 1922).
Flood Protection Data (Authorized April 4, 1922).
Irrigation Hydraulics (Authorized April 4, 1922).
Hydraulics Phenomena (Authorized April 4, 1922).
Concrete and Reinforced Concrete Arches (Authorized January 16, 1923).
Steel Column Research (Authorized January 16, 1923).
Effects of Earthquakes on Engineering Structures with Special Reference to the Japanese Earthquake of September 1, 1923 (Authorized October 16, 1923).
Cement (Authorized October 22, 1924).
Arbitration (Authorized January 19, 1925).
Engineering Contract Bonding (Authorized January 22, 1925).
City Planning of Washington, D. C. (Authorized April 20, 1925).

Gifts for Committee Work

Engineering Foundation has continued its generous policy in assisting the financing of research committees of the Society. During the past year it has contributed \$3 000 to the work of the Special Committee on Concrete and Reinforced Concrete Arches, and \$1 000 to the Committee on Steel Column Research. Contributions have also been received for the work of this latter Committee from the American Bridge Company, \$250, and from the McClintic-Marshall Company, \$250.

It is impossible to acknowledge individually the assistance given by many members of the Society in thought and time, and the Board of Direction again wishes to express its appreciation of these gifts.

PUBLICATIONS

Ten numbers of *Proceedings,* one volume of *Transactions,* a Year Book, and a new edition of the pamphlet entitled "Aims and Activities", have been published in 1925.

The stock of the various publications of the Society kept on hand for the convenience of members and others now amounts to 86 344 copies, the cost of which to the Society for paper and press work only, has been $20 186.

The table (see page 11) shows the cost per page for text and illustrations in *Proceedings* and *Transactions* for the past twelve years. It will be noted that, through intensive effort on the part of the Editorial Department, the cost per page is now at approximately the same figure as it was before the rise in prices following the World War.

Summary of Publications for 1925

	Issues	Average edition	Total pages	Plates	Cuts
Proceedings (monthly numbers).....	10	11 800	2 910	7	650
Transactions, Vol 88..............	1	11 400	1 538	5	439
Year Book........................	1	11 700	446	1	...
"Aims and Activities"............	1	16 000	38	1	3
Total	13	....	4 932	14	1 092

The cost of publications, as determined by the bills actually paid during the year has been:

For Paper, Printing, etc., *Proceedings*......................	$24 910.70
For Paper, Printing, etc., of 20 665 Extra Copies of Papers, Discussions, Memoirs..............................	892.39
For Paper, Printing, etc., *Transactions* Vol. 88...............	8 785.15
For 4 275 Extra Copies of Separate Papers for *Transactions* Vol. 88	837.99
For Binding, Envelopes, etc., *Proceedings*....................	5 302.72
For Binding,* Boxes, etc., *Transactions* Vol. 88...............	1 883.86
For Plates and Cuts..	6 442.69
For Year Book..	5 309.66
For "Aims and Activities"....................................	815.92
For Copyright and Sundry Expenses............................	83.95
Total	$55 265.03
Deduct amount received from sale of publications............	6 915.84
Net expenditures for publications for 1925..................	$48 349.19

* Paper binding only.

TABLE SHOWING NUMBER AND COST OF PAGES AND COST OF ILLUSTRATIONS FOR *Transactions* AND *Proceedings*.

Year.	*TRANSACTIONS.*				*PROCEEDINGS.*				*PROCEEDINGS and TRANSACTIONS.*			ILLUSTRATIONS.		
	Issues.	Edition.	PAGES.		Issues.	Edition.	PAGES.		Total pages.	Total cost.	Cost per page.	Cost.	Percentage of total cost.	Cost per page.
			Per volume.	Total.			Per volume.	Total.						
1913	1	7 700	2 302	17 740 000	10	7 625	3 184	24 280 000	42 020 000	$43 329.77	$0.00103	$3 964.16	9.1	$0.000094
1914	1	8 200	1 968	16 140 000	10	8 150	4 076	33 220 000	49 360 000	39 083.89	0.00079	2 963.32	7.6	0.000075
1915	2	8 600	3 130	26 900 000	10	8 425	3 668	30 900 000	57 800 000	47 934.16	0.00083	3 684.68	7.7	0.000064
1916	1	8 400	2 301	19 330 000	10	8 350	2 892	24 140 000	43 470 000	35 645.65	0.00082	1 403.12	3.9	0.000032
1917	..	.....	......	....	10	8 550	3 432	29 350 000	29 350 000	28 608.18	0.00097	3 703.97	12.9	0.000126
1918	1	8 700	1 879	16 340 000	10	8 950	2 341	20 950 000	37 290 000	33 785.64	0.00091	1 192.20	3.5	0.000032
1919	1	9 000	1 775	15 980 000	8	9 100	2 096	19 075 000	35 055 000	32 082.69	0.00091	1 128.53	3.5	0.000032
1920	..	.....	......	....	10	10 142	2 014	20 440 000	20 440 000	23 446.34	0.00115	2 552.27	10.9	0.000125
1921	2	10 000 10 500	2 479 993	35 212 000	10	10 680	1 834	19 450 000	54 662 000	66 298.39	0.00121	2 034.72	3.1	0.000037
1922	1	10 900	1 826	19 900 000	10	11 100	2 740	30 400 000	50 300 000	56 200.00	0.00112	3 700.00	6.6	0.000073
1923	1	11 200	1 808	20 250 000	10	11 500	3 210	36 915 000	57 165 000	60 612.83	0.00106	4 809.88	7.9	0.000084
1924	1	11 500	1 515	17 440 000	10	11 750	2 612	30 700 000	48 140 000	47 578.72	0.00099	4 579.04	9.6	0.000095
1925	1	11 400	1 538	17 533 000	10	11 800	2 910	34 338 000	51 871 000	47 409.07	0.00091	6 359.19	13.4	0.000122

The subjects of the papers and discussions in *Proceedings* and *Transactions* during the year, and the number of pages devoted to each, follows:

	Transactions	*Proceedings*
Hydrology, Hydraulics	4	194
Highway Engineering	42	16
Dams	158	115
Structural Engineering	322	364
Materials of Engineering	....	157
Soils	....	18
Railways	167	186
Waterways	172	233
Water-Power	100	144
Water Works	....	85
Sanitation	15	184
Sewage Disposal	73	6
City Planning	263	233
Engineering History	12	14
Fire Prevention	....	33
Total	1 328	1 932

MEETINGS

Twelve meetings of 16 sessions, were held during the year as follows: At the Annual Meeting, 1 (2 sessions); at the Annual Convention at Cincinnati, Ohio, 1 (2 sessions); at the Summer Meeting at Salt Lake City, Utah, 1 (2 sessions); at the Fall Meeting at Montreal, Que., Canada, 1 (2 sessions); and 8 other meetings. All the New York meetings, including the Annual Meeting, were held at Society Headquarters in the Engineering Societies Building.

At these meetings, there were presented 17 formal papers, 9 of which were illustrated with motion pictures and lantern slides, 1 Symposium (4 papers), and 1 Address.

During the year, there were also published 7 Progress Reports and 1 Final Report of Special Committees, all of which were presented at the Annual Meeting, and 9 papers that were not presented at any meeting of the Society, as well as an Appendix to the Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete, by W. A. Slater, M. Am. Soc. C. E., and Stanton Walker, Esq.

The number of members and others who took part in the preparation and discussion of these papers, symposium, address, and reports of Special Committees, was about 320. This figure does not include those who took part in the preparation and discussion of papers presented at the meetings of the Technical Divisions which are listed on pages 15 to 17.

The total attendance at the 12 meetings of the Society was about 2 475. The registered attendance at the Annual Meeting was 913; at the Annual Convention 274; at the Summer Meeting 235; and at the Fall Meeting 479.

The meetings of the Society during the year, together with the papers, symposiums, reports of Special Committees, etc., presented thereat, are as follows:

January 21, 1925, Progress Reports of Special Committees on Impact on Highway Bridges, Bearing Value of Soils for Foundations, etc., Stresses in

Railroad Track, Standard Construction Contracts, Concrete and Reinforced Concrete Arches, Electrification of Steam Railways, Flood Protection Data, Irrigation Hydraulics, Hydraulics Phenomena, Steel Column Research, and Bridge Design and Construction, and the Final Report on Stresses in Structural Steel.

February 4, 1925, "Design of Symmetrical Concrete Arches", by Charles S. Whitney, M. Am. Soc. C. E.

March 4, 1925, "Sherman Island Dam and Power-House", by H. de B. Parsons, M. Am. Soc. C. E.

April 22, 1925, Symposium on "Relation of the Ohio River and Its Tributaries to Transportation in the United States", by C. W. Kutz, H. B. Luther, and Frank H. Alfred, Members, Am. Soc. C. E., and Julian A. Pollak, Esq.

May 6, 1925, "Flood Flow Characteristics", by C. S. Jarvis, M. Am. Soc. C. E.

June 3, 1925, "Fire-Banks for Oil Storage", by H. H. Hall, M. Am. Soc. C. E.

July 8, 1925 (Two Sessions) "History and Problems of Irrigation Development in the West", by Dr. John A. Widtsoe; "The Financing of Irrigation Development by Private Capital", by R. E. Shepherd, Esq.; "Co-Operation in Irrigation and Power Development", by William Kelly, M. Am. Soc. C. E.; "Present Policy of the U. S. Bureau of Reclamation Regarding Land Settlement", by Elwood Mead, M. Am. Soc. C. E.; "Land Settlement of Irrigation Projects", by Augustus Griffin, M. Am. Soc. C. E.; and "Irrigation Development Through Irrigation Districts", by E. Courtland Eaton, M. Am. Soc. C. E., and Frank Adams, M. Am. Soc. C. E.

September 2, 1925, "The Reinforced Concrete Arch in Sewer Construction", by Charles E. Sharp, Jr., Esq.

October 7, 1925, "Multiple-Arch Dam at Gem Lake on Rush Creek, California", by Fred O. Dolson and Walter L. Huber, Members, Am. Soc. C. E.

October 14, 1925 (Two Sessions) "Work of the Quebec Streams Commission", by O. O. Lefebvre, Esq.; "Developments by the Hydro-Electric Power Commission of Ontario", by Frederick A. Gaby, M. Am. Soc. C. E.; "Some Economic Aspects of Hydro-Electric Development in Canada", by Ira W. McConnell, M. Am. Soc. C. E.; and Informal Discussion on Hydro-Electric Development in Canada.

November 4, 1925, "The Oradell Dam of the Hackensack Water Company", by Nicholas S. Hill, Jr., M. Am. Soc. C. E.

December 9, 1925, "The Utilizable Capacity of Steel Members of Structures", by Henry S. Prichard, M. Am. Soc. C. E.

The papers published in *Proceedings,* but not presented at any meeting of the Society were, as follows:

January, 1925, "Report on Field Tests of Concrete Used in Construction Work: Submitted to the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete", by W. A. Slater, M. Am. Soc. C. E., and Stanton Walker, Esq.; "Repairing Leaks in a Dry Dock by Grouting", by W.

Mack Angas, Esq.; and "Hydro-Electric Power as a By-Product of Agricultural Storage", by Everett N. Bryan, Assoc. M. Am. Soc. C. E.

August, 1925, "The Engineer as a Railroad Executive", by the late Julius Kruttschnitt, Esq.

September, 1925, "The Improved Venturi Flume", by Ralph L. Parshall, Affiliate, Am. Soc. C. E.; "Side Channel Spillways: Hydraulic Theory, Economic Factors, and Experimental Determination of Losses", by Julian Hinds, M. Am. Soc. C. E.; and "Permissible Canal Velocities", by Samuel Fortier and Fred C. Scobey, Members, Am. Soc. C. E.

October, 1925, "Moments in Restrained and Continuous Beams by the Method of Conjugate Points", by L. H. Nishkian, and D. B. Steinman, Members, Am. Soc. C. E.

November, 1925, "Hexagonal Slab Design of Concrete Pavements", by Lewis A. Perry, Assoc. M. Am. Soc. C. E.

December, 1925, "Notes on Shear in Compression Members", by Ralph E. Goodwin, Assoc. M. Am. Soc. C. E.

MEDALS AND PRIZES

The award of medals and prizes for the year ending July, 1925, was as follows:

The Norman Medal to Harrison Prescott Eddy, M. Am. Soc. C. E., for his paper entitled "Imhoff Tanks—Reasons for Differences in Behavior".

The J. James R. Croes Medal to Charles Smith Whitney, M. Am. Soc. C. E., for his paper entitled "Design of Symmetrical Concrete Arches".

The Thomas Fitch Rowland Prize to Harry de Berkeley Parsons, M. Am. Soc. C. E., for his paper entitled "Sherman Island Dam and Power-House".

The James Laurie Prize to William Kelly, M. Am. Soc. C. E., for his paper entitled "The Colorado River Problem".

The Arthur M. Wellington Prize to William Murray Black, M. Am. Soc. C. E., for his paper entitled "Waterway and Railway Equivalents".

LOCAL SECTIONS

There are at present 45 Local Sections, one of which, Arizona, was organized during 1925.

These Sections are contributing notably to the welfare of the Society by definitely encouraging interest in its affairs in their respective communities.

The Board has endeavored to further these efforts by authorizing the Secretary to visit thirty-two Sections during the past year. The President also found it practicable to make visits to eleven Local Sections.

The allotments to Local Sections have been continued, and the amount paid to them in 1925 was $7 400.

TECHNICAL DIVISIONS

Meetings of the City Planning, Highway, Irrigation, Power, Sanitary Engineering, Structural and Waterways Divisions have been held during the year.

The membership has shown an active interest in the work and activities of the various Divisions as is evidenced by the seventeen Divisional programs during the year. The Technical Divisions have served not only to broaden the scope of the Quarterly Meetings but also have enlarged the field covered by the *Proceedings* through the Division papers that have been published. In this manner the Division has been the agency for interesting a large number of members in the work of the Society, and has contributed greatly to the Quarterly Meetings and the Society publications.

The meetings of the Divisions during the year, together with the papers presented thereat, are as follows:

City Planning Division

January 23, 1925 (Two Sessions), "Excess Condemnation in City Planning": "Scope of City Planning", by Allen J. Saville, M. Am. Soc. C. E.; "The Present Status of Excess Condemnation in the United States",* by Frank B. Williams, Esq.; "The Use of Excess Condemnation in the Opening, Widening, and Extension of Streets",† by A. L. Vedder, Assoc. M. Am. Soc. C. E.; "The Need and Scope of Excess Condemnation",‡ by Charles Wellford Leavitt, M. Am. Soc. C. E.; and "Excess Condemnation in Massachusetts",§ by Frederic H. Fay, M. Am. Soc. C. E.

July 9, 1925, "The Development of Industrial Sites and Track Layouts at Kansas City, Kans. and Los Angeles, Calif., by the Union Pacific Railroad Company", by Walter R. Armstrong, M. Am. Soc. C. E.

October 15, 1925 (Joint Session with the Town Planning Institute of Canada), "The Engineer and the Town Plan", by James Ewing, Esq.; and "Aerial Photographic Maps for City Planning", by Gerard H. Matthes, M. Am. Soc. C. E.

Highway Division

January 22, 1925 (Two Sessions), "Elements Governing the Development of Highway Traffic",‖ by A. N. Johnson, M. Am. Soc. C. E.; "Recent Developments in Highway Research", by Charles M. Upham, M. Am. Soc. C. E.; and "Effect of Moisture on Concrete",¶ by W. K. Hatt, M. Am. Soc. C. E.

July 9, 1925, "Snow Removal Problems of Organization and Operation", by George E. Hamlin, M. Am. Soc. C. E., and "Finishing and Curing Concrete Roads", by C. L. McKesson, Assoc. M. Am. Soc. C. E.

Irrigation Division

July 9, 1925, Determination of the Duty of Water in the Adjudication of Water Rights: Report of the Duty of Water Committee of the Division;

* *Proceedings*, Am. Soc. C. E., September, 1925, Papers and Discussions, p. 1416.
† *Loc. cit.*, p. 1420.
‡ *Loc. cit.*, p. 1425.
§ *Loc. cit.*, p. 1440.
‖ *Loc. cit.*, May, 1925, Papers and Discussions, p. 748.
¶ *Loc. cit.*, p. 757.

"Consumptive Duty of Water", by O. W. Israelson, Esq.; "Co-Operation Between Federal and State Agencies in Irrigation Investigations", by Fred C. Scobey, M. Am. Soc. C. E.; and "Interstate Water Problems and Their Solution", by M. C. Hinderlider, M. Am. Soc. C. E., and R. I. Meeker, Assoc. M. Am. Soc. C. E.

Power Division

January 22, 1925, Symposium* on "High Specific Speed Hydraulic Turbines in Their Bearing on the Proportioning of the Number of Units in Low-Head Hydro-Electric Plants"; "High Specific Speed Turbines", by George A. Orrok, M. Am. Soc. C. E.; "The Propeller Type Turbine", by Lewis F. Moody, Esq.; "High-Speed Suction Turbines" by Forrest Nagler, M. Am. Soc. C. E.; "High Specific Speed Hydraulic Turbines in Their Bearing on the Proportioning of the Number of Units in Low-Head Hydro-Electric Plants", by George A. Jessop, Assoc. M. Am. Soc. C. E.; "Some Applications of the Propeller Type Water Turbine in Europe", by Charles C. Egbert, Esq.; and "Proportioning of Units in Low-Head Plants", by John P. Hogan, M. Am. Soc. C. E.

April 23, 1925, "The Dix River Dam of the Kentucky Hydro-Electric Company", by L. F. Harza, M. Am. Soc. C. E.; and "Steam Power Plant at the Mouth of the Big Miami River", by S. D. Heed, Assoc. M. Am. Soc. C. E.

July 9, 1925, "The Relation of Stream Regulation to Irrigation and Power Development", by J. C. Stevens, M. Am. Soc. C. E.

Sanitary Engineering Division

January 22, 1925 (Two Sessions), "Laws Relating to Obnoxious Odors",† by Irving I. Goldsmith, Esq.; "Methods of Determining Source and Extent of Obnoxious Odors",‡ by Stephen DeM. Gage, Esq.; "Elimination of Odors from Garbage Disposal Plants",§ by Samuel A. Greeley, M. Am. Soc. C. E.; "Control of Odors from Sewage Treatment Plants",‖ by John F. Skinner, M. Am. Soc. C. E.; and "The Detection and Elimination of Odors from Oil Refineries",¶ by Robert Spurr Weston, M. Am. Soc. C. E.

April 23, 1925, Symposium on "Stream Pollution":** "A Review of the Work of the U. S. Public Health Service in Investigations of Stream Pollution", by W. H. Frost, M. D. "The Rate of Deoxygenation of Polluted Waters", by E. J. Theriault, Esq.; "The Rate of Atmospheric Reaeration of Sewage Polluted Streams", by H. W. Streeter, M. Am. Soc. C. E.; "Quantitative Studies of Bacterial Pollution and Natural Purification in the Ohio and Illinois Rivers", by J. K. Hoskins, Esq.

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* *Proceedings*, Am. Soc. C. E., August, 1925, Papers and Discussions, p. 999.
† *Loc. cit.*, May, 1925, Papers and Discussions, p. 811.
‡ *Loc. cit.*, p. 820.
§ *Loc. cit.*, p. 832.
‖ *Loc. cit.*, p. 847.
¶ *Loc. cit.*, p. 854.
** *Loc. cit.*, November, 1925, Papers and Discussions, p. 1809.

October 15, 1925, "The Water Supply of Montreal, Que., Canada", by F. E. Field, M. Am. Soc. C. E.; Symposium on "Grit Chamber Practice"; "Canadian Practice", by F. A. Dallyn, Esq.; "Grit Chamber Design", by George B. Gascoigne, M. Am. Soc. C. E.; "German Practice in Grit Chamber Design", by Karl Imhoff, M. Am. Soc. C. E.; and "British Practice in the Design of Grit Chambers or Detritus Tanks", by Arthur J. Martin, Esq.

Structural Division

January 22, 1925 (Two Sessions), Organization Meeting.

July 9, 1925, Symposiums on "The Object and Scope of the Work of the Structural Division"; "Working Stresses in Steel Construction"; and "Reinforced Concrete-Unit Stresses and Field Control".

October 15, 1925, "Producing a Concrete of Uniform Quality on the Job: The Factors Fundamental to Success, with Observations Based on Six Years' Experience", by R. B. Young, Esq.; "Concrete Proportioning and Testing at Exchequer Dam", by L. H. Tuthill, Esq.; and "Water Ratio Specification for Concrete", by F. R. McMillan, M. Am. Soc. C. E.

Waterways Division

April 23, 1925, Organization Meeting.

Membership of Divisions

The interest taken by the membership in the Technical Divisions is plainly shown in the increase in membership from 1 861 in 1923 to 5 617 at present. The membership of these Divisions is as follows:

City Planning Division	701
Construction Division	355*
Highway Division	1 248
Irrigation Division	545
Power Division	439
Sanitary Engineering Division	932
Structural Division	1 165
Waterways Division	232
Total	5 617

STUDENT CHAPTERS

There are at present 45 students who have taken advantage of the By-Law which enables them to continue affiliation with their Chapters until the first day of the second January following graduation.

* Organization not yet complete.

New Student Chapters

There are now 76 Student Chapters, the total membership of which is 3 858. Seven new Chapters were organized during the year:

Antioch College
Armour Institute of Technology
Cooper Union
Robert H. McNeilly (Vanderbilt University)
University of Georgia
University of Wyoming
Villanova College

FINANCES

The finances of the Society are in good condition. The balance of cash on hand and fluid funds in short-time securities but exclusive of sums held in trust for certain Special Committees and Technical Divisions, is approximately $97 769 as against $85 704 at the end of 1924. Since the beginning of the year this figure has increased about $12 065 and, in addition, $40 000 has been paid on the mortgage on the Fifty-seventh Street property. A large element in this increase of funds has been the persistent effort of the Executive Committee to collect current and past dues. This has brought in about $14 274 more than was similarly collected in 1924, which sum, in addition to other outstanding indebtedness collected, has permitted the reduction on the General Balance Sheet of such accounts carried as Assets from $29 113.81 to $13 180.35. A marked economy in the cost of the publications of the Society also has been effected, largely as a result of certain business methods instituted by the staff and carried out under the direction of the Committee on Technical Activities and Publications. This permitted a larger output with also a slight reduction in net cost.

The reports of the Secretary and the Treasurer are appended.

By order of the Board of Direction,

George T. Seabury, *Secretary*.

January 18, 1926.

October 15, 1925, "The Water Supply of Montreal, Que., Canada", by F. E. Field, M. Am. Soc. C. E.; Symposium on "Grit Chamber Practice"; "Canadian Practice", by F. A. Dallyn, Esq.; "Grit Chamber Design", by George B. Gascoigne, M. Am. Soc. C. E.; "German Practice in Grit Chamber Design", by Karl Imhoff, M. Am. Soc. C. E.; and "British Practice in the Design of Grit Chambers or Detritus Tanks", by Arthur J. Martin, Esq.

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The reports of the Secretary and the Treasurer are appended.

By order of the Board of Direction,

GEORGE T. SEABURY, *Secretary.*

January 18, 1926.

REPORT OF THE SECRETARY FOR THE

TO THE BOARD OF DIRECTION OF THE

GENTLEMEN:—I have the honor to present a statement of Receipts and Disbursements for the fiscal year of the Society, ending December 31, 1925. There is also appended a general Balance Sheet showing the condition of the affairs of the Society.

Respectfully submitted,

GEORGE T. SEABURY,

Secretary.

RECEIPTS

Balance on hand January 1, 1925*		$59 944.32
Entrance Fees	$16 800.00	
Current Dues	156 523.32	
Past Dues	15 794.51	
Advance Dues	53 330.61	
Sale of Publications	6 915.84	
Binding of *Transactions*	8 329.68	
Badges	4 707.75	
Certificates of Membership	756.50	
Annual Meeting	5 024.12	
For Power Division:		
1925 Dues	297.00	
1926 Dues	116.00	
For City Planning Division	45.00	
Interest on Bank Balance	1 342.62	
Interest on Bonds	2 147.75	
Postage	177.80	
Miscellaneous	832.93	
Rent from 57th Street Property	22 703.32	
The Freeman Fund	1 565.00	
From Engineering Foundation in Credit to Special Committee on Steel Column Research	1 500.00	
From Engineering Foundation in Credit to Special Committee on Concrete and Reinforced Concrete Arches	3 000.00	
Maturity of U. S. Treasury Notes	25 000.00	326 909.75
		$386 854.07

*Society Funds in Garfield National Bank	$45 189.30	
Petty Cash (in hands of Secretary)	5 000.00	
In Chase National Bank	500.00	$50 689.30
For Special Committee on Stresses in Railroad Track		4 856.10
For Special Committee on Concrete and Reinforced Concrete Arches		1 361.55
For Special Committee on Steel Column Research		707.85
1923 Dues Collected for Power Division	$243.80	
1924 Dues Collected for Power Division	354.00	
1925 Dues Collected for Power Division	134.00	731.80
To Establish the Rudolph Hering Medal		1 562.72
For the Freeman Fund		35.00
		$59 944.32

YEAR ENDING DECEMBER 31, 1925

American Society of Civil Engineers.

Disbursements

Salaries of Officers		$16 117.40	
Retirement Allowances		7 500.00	
Clerical Help		57 734.79	
Publications		55 265.03	
Binding of *Transactions*		4 214.85	
General Printing		3 711.07	
Badges		3 496.27	
Certificates of Membership		511.89	
Annual Prizes		329.41	
Meetings:			
Annual Meeting		8 391.28	
Annual Convention 1924		468.76	
Annual Convention 1925		1 050.58	
Annual Summer Meeting		1,114.29	
Annual Fall Meeting		1 816.15	
Monthly Meetings		1 314.41	
Local Sections		7 400.00	
Technical Divisions:			
Sanitary		468.71	
Power		282.54	
Irrigation		211.91	
Highway		420.75	
City Planning		469.35	
Structural		746.54	
Waterways		39.87	
Traveling Allowance of Officers		14 347.80	
Traveling Allowance of Standing Committees		427.92	
Work of Committees:			
Mileage		4 634.71	
Other Expenditures		10 617.98	
Reading Room		467.35	
Employment Service		1 815.00	
Office Supplies		2 531.03	
Postage		10 851.90	
Furniture and Office Equipment		3 724.74	
Current Business		3 059.89	
United Engineering Society:			
General Assessment		6 450.96	
Library		8 000.00	
Telephone		980.60	
John Fritz Medal Board		164.72	
Payment on Mortgage on 57th Street Property		40 000.00	
Interest on Mortgage on 57th Street Property		9 000.00	
Premium on Insurance		411.58	
Miscellaneous		844.59	
Purchase of Certificate of Deposit		25 000.00	
Rudolph Hering Medal		400.00	
			$316 806.62
December 31, 1925, Cash on Hand			70 047.45*
			$386 854.07

*Society Funds in Garfield National Bank	$57 269.15		
Petty Cash (in hands of Secretary)	5 000.00		
In Chase National Bank	500.00	$62 769.15	
For Special Committee on Stresses in Railroad Track		3 325.78	
Collected for Power Division:			
1923 Dues	243.80		
1924 Dues	354.00		
1925 Dues	431.00		
1926 Dues	116.00	1 144.80	
Collected for City Planning Division		45.00	
Unexpended Balance of Funds Collected for the Rudolph Hering Medal		1 162.72	
For the Freeman Fund		1 600.00	
		$70 047.45	

GENERAL BALANCE SHEET

ACCOMPANYING THE REPORT

ASSETS

Real Estate :			
One-fourth interest in U. E. S. real estate, 25 to 33 West 39th Street, New York, N. Y.		$491 642.36	
220 West 57th St., New York, N. Y. Three lots (actual cost $185 406.20) Estimated Value....		350 000.00	
Building with Improvements at Cost.	$242 029.99		
Less reserve for depreciation..	68 691.61	173 338.38	$1 014 980.74
Equipment :			
Furniture and office equipment		$59 937.13	
Less reserve for depreciation		31 933.12	28 004.01
Library :			
Cash expended for books, etc		$22 122.22	
Donations (estimated)		72 310.83	94 433.05
Investments :			
$10 000 4¼% New York City bonds (at par)		$10 000.00	
$27 300 4¼% Liberty Bonds (at cost)		27 007.25	
$35 000 2½% Certificates of Deposit (at cost)		35 000.00	
The Freeman Fund :			
260 shares of miscellaneous stocks (market value on day of acquisition)		23 410.00	95 417.25
Working Assets :			
Publications on hand (book inventory) (at cost)..		$20 186.33	
Unexpired insurance premium		147.00	20 333.33
Current Assets :			
Cash on hand	$57 769.15		
Petty cash, in hands of Secretary ..	5 000.00	$62 769.15	
For Committee on Stresses in Railroad Track....		3 325.78	
1923 dues collected for Power Division.	$243.80		
1924 " " " " " .	354.00		
1925 " " " " " .	431.00		
1926 " " " " " .	116.00	1 144.80	
Collected for the City Planning Division		45.00	
For the Freeman Fund		1 600.00	
Unexpended balance of contributions to the Rudolph Hering Medal		1 162.72	70 047.45
Due from members (past due)		$13 180.35	
" " non-members		2 682.22	
Interest accrued on investments to December 31, 1925		1 044.85	16 907.42
			$1 340 123.25

We have audited the accounts of the AMERICAN SOCIETY OF CIVIL
estimate of the property and Library valuations and book inventory of publi-
sheet sets forth correctly the financial condition of the Society at that date.

NEW YORK, January 14, 1926.

DECEMBER 31, 1925.

OF THE SECRETARY.

LIABILITIES

1926 dues paid in advance (including $116.00 for Power Division)		$53 446.61
Interest accrued on mortgage to December 31, 1925		3 333.30
Unexpended balance for Committee on Stresses in Railroad Track		3 325.78
1923 dues credited to Power Division	$244.00	
1924 " " " " "	372.00	
1925 " " " " "	443.00	1 059.00
Collected for City Planning Division		45.00
Unexpended balance of contributions to the Rudolph Hering Medal		1 162.72
Income from the Freeman Fund		1 600.00
Mortgage payable, due February 1, 1929		160 000.00
Funds :		
Herbert Steward Library Fund	$ 2 000.00	
Joseph G. Swift " "	1 000.00	
Compounding Dues Fund	15 480.00	
Norman Medal Fund	1 000.00	
Rowland Prize Fund	1 222.50	
Collingwood Prize Fund	1 000.00	
Arthur M. Wellington Prize Fund	2 150.00	
Fellowship Fund	13 038.28	
Hiram F. Mills Legacy	2 000.00	
The Freeman Fund	23 410.00	
Reserve Fund	33 116.47	95 417.25
Surplus		1 020 733.59
		$1 340 123.25

ENGINEERS for the year ended December 31, 1925, and (assuming that the cations on hand are correct) we certify that, in our opinion, the above balance

LYBRAND, ROSS BROS. & MONTGOMERY,
Accountants and Auditors.

REPORT OF THE TREASURER OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS FOR THE YEAR ENDING DECEMBER 31, 1925

In compliance with the provisions of the Constitution, I have the honor to present the following report:

Cash on Hand January 1, 1925			$59 944.32
RECEIPTS			
From current sources, January 1 to December 31		$272 683.43	
1925 Dues collected for Power Division		297.00	
1926 " " " " "		116.00	
For City Planning Division		45.00	
Rent from 57th Street Property		22 703.32	
From Engineering Foundation for:			
Special Committee on Concrete and Reinforced Concrete Arches		3 000.00	
Special Committee on Steel Column Research*.		1 500.00	
The Freeman Fund Investments		1 565.00	
Maturity of 25 000–4½% U. S. Treasury Notes		25 000.00	326 909.75
DISBURSEMENTS			
Payment of Bills by audited vouchers for current business, January 1–December 31		$241 766.95	
Local Sections		7 400.00	
Technical Divisions		2 639.67	
Payment on Mortgage, 57th Street Property		40 000.00	
Certificate of Deposit		25 000.00	
Balance on hand December 31, 1925:			
In Garfield National Bank	$64 547.45		
In hands of Secretary	5 000.00		
In Chase National Bank	500.00	70 047.45	
		$386 854.07	$386 854.07

Respectfully submitted,

OTIS E. HOVEY,
Treasurer.

* Contributed by Engineering Foundation	$1 000.00	
" " American Bridge Co.	250.00	
" " McClintic-Marshall Co.	250.00	$1 500.00

Annual Reports of the Technical Divisions

Annual Report of the City Planning Division for 1925

The City Planning Division of the American Society of Civil Engineers respectfully submits to the Board of Direction this report of operations for the year 1925.

At the beginning of 1925 the membership was 445, which has been increased during the year to 702, including Division Affiliates to the number of 15.

Programs were arranged for the Annual Meeting, the Salt Lake City Meeting, and the Montreal Meeting. The joint session at Montreal with the City Planning Institute of Canada proved a success. President Cauchon officiated as Chairman for a part of the meeting and a paper was presented by Mr. James Ewing, a member of the Institute.

Classification cards identifying the interest of members in special topics of City Planning were sent out to, and returned by, many of the members, making available information of considerable value.

In accordance with the suggestion offered by the City Planning Division, a committee of six members of the Society was appointed by the Board of Direction to co-operate with other National organizations in the development of City Planning for the District of Columbia. The Chairman, Mr. Morris Knowles, and two other members of the Committee were chosen from the Executive Committee of the Division. Two sessions of the Committee have been held in Washington, and in co-operation with other interested persons, a bill has been drafted for presentation to Congress, which it is believed will secure united widespread support.

EDWIN A. FISHER, *Chairman*, Executive Committee,
CHARLES B. BALL, *Secretary.*

Annual Report of the Highway Division for 1925

The affairs of the Highway Division have been directed during 1925 by an Executive Committee consisting of Messrs. T. R. Agg, L. D. Blauvelt, C. D. Curtiss, H. G. Shirley, and T. J. Wasser. Mr. Agg has served as Chairman and Mr. Curtiss as Secretary.

Only one meeting of the Executive Committee was held during 1925. This meeting was on January 23 and was attended by Messrs. Agg, Shirley, and Curtiss. At this meeting it was decided to hold a meeting of the Division in Salt Lake City, Utah, in connection with the Summer Meeting of the Society but not to hold one in connection with the Annual Convention in Cincinnati, Ohio. The question of a meeting in connection with the Fall Meeting of the Society in Montreal, Que., Canada, was left for later settlement, but with the idea that the Committee would be governed largely by the wishes of the Local Committee in Montreal. Following this one meeting of the Executive Committee all business of the Division has been conducted by correspondence. The Secretary has had opportunity for personal conferences with several members

of the Committee at various times during the year, however, at which times Division matters have been discussed.

In compliance with the Constitution of the Highway Division the following Nominating Committee was appointed to make nominations for members of the Executive Committee for 1926: C. J. Tilden, *Chairman,* W. W. Crosby, A. B. Fletcher, A. T. Goldbeck, and Clifford Older. This Committee nominated the following: Messrs. C. D. Curtiss, Arthur N. Johnson, Paul D. Sargent, Frank T. Sheets, and Thomas E. Stanton, Jr. These names were sent out for letter ballot to members of the Division and the results will be canvassed January 18, 1926.

After correspondence with the Local Committee in Montreal, it was decided not to hold a meeting of the Division there at the time of the Fall Meeting of the Society, so only two meetings of the Division were held during 1925.

The first meeting was held in the Auditorium of the Engineering Societies Building in New York, N. Y., January 22, 1925, in connection with the Seventy-second Annual Meeting of the Society. Following the reading of the Annual Report of the Division Secretary, A. N. Johnson, M. Am. Soc. C. E., Dean of the Engineering College, University of Maryland, read a paper on "Elements Governing the Development of Highway Traffic".* This paper was discussed by William H. Connell, M. Am. Soc. C. E., Engineering Executive and Acting Secretary, Pennsylvania Department of Highways; T. R. Agg, M. Am. Soc. C. E., Professor of Highway Engineering, Iowa State College; and Arthur W. Dean, M. Am. Soc. C. E., Chief Engineer, Division of Highways, Massachusetts Department of Public Works. At the afternoon session papers on "Recent Developments in Highway Research" were read by C. N. Conners, Assistant Engineer to the Chief Engineer, North Carolina Highway Department, and H. F. Janda, Assistant Director, Advisory Board on Highway Research, National Research Council. This was followed by a paper on "Effect of Moisture on Concrete"† by William K. Hatt, M. Am. Soc. C. E., Professor of Civil Engineering, Purdue University. This paper was discussed by A. T. Goldbeck, Assoc. M. Am. Soc. C. E., Director, Bureau of Engineering, National Crushed Stone Association. The following resolutions were passed at this meeting:

"*Resolved,* That the Board of Direction be and is hereby requested to appoint a Committee to co-operate with similar committees from the American Institute of Architects, the Associated General Contractors, and the American Association of State Highway Officials in endeavoring to find some solution for existing abuses in the writing of contract bonds."

"*Be It Resolved,* That the Permanent International Association of Road Congresses should be joined by the United States of America; and,

"That such Governmental action as may be necessary to that end should be had as promptly as practicable in order that the United States may be properly represented at the Fifth International Congress to be held in Milan, Italy, in September, 1926."

"*Whereas,* There is a Bill in Congress providing for the re-organization of the Government departments, which in its present form proposes to substi-

* *Proceedings,* Am. Soc. C. E., May, 1925, Papers and Discussions, p. 748.

† *Loc. cit.,* p. 757.

tute a subordinate Division of Public Works within an existing department, for the Department of Public Works endorsed by the Board of Direction of this Society, which proposed division will belittle the position of the engineer in public service rather than give him the recognition he deserves and which was contemplated in the plan for a Department of Public Works; and,

"*Whereas,* Since the proposed transfer of the Bureau of Public Roads of the Department of Agriculture to a subordinate position in the proposed Division of Public Works, and consequent division of its present functions, cannot fail to interfere with the successful co-operative relations with all State highway departments and the continuation of its extensive research work, thus bringing about a condition which highway engineers would deplore; now

"*Therefore, Be It Resolved* that the Highway Division affirms the stand of the Board of Direction for a Department of Public Works and respectfully petitions the Board of Direction to oppose the proposed scheme of re-organization as far as it relates to the engineering agencies of the Government and particularly to oppose the transfer of the Bureau of Public Roads from the Department of Agriculture until a real executive Department of Public Works is provided for."

The sessions were well attended and were presided over by Chairman Shirley.

The second meeting was held in Salt Lake City, Utah, July 9, 1925, in connection with the Summer Meeting of the Society. The program was opened by George E. Hamlin, M. Am. Soc. C. E., Superintendent of Repairs, Connecticut State Highway Department, with a paper on "Snow Removal Problems of Organization and Operation." This was discussed by Howard C. Means, M. Am. Soc. C. E., Chief Engineer, Utah State Road Commission, and B. J. Finch, District Engineer, U. S. Bureau of Public Roads, and was followed by a paper on "Finishing and Curing Concrete Roads", by C. L. McKesson, Assoc. M. Am. Soc. C. E., Materials and Research Engineer, California State Highway Commission. Following the discussion of this paper, a motion picture showing the construction of the "Wendover Cut-Off", a very difficult piece of road work over the Great Salt Desert west of Salt Lake City, built by the State of Utah and the Federal Government as a Federal Aid Project, was presented. Mr. Means explained various features of the work during the showing of the film.

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C. D. CURTISS,
Secretary, Highway Division.

of the Committee at various times during the year, however, at which times Division matters have been discussed.

In compliance with the Constitution of the Highway Division the following Nominating Committee was appointed to make nominations for members of the Executive Committee for 1926: C. J. Tilden, *Chairman*, W. W. Crosby, A. B. Fletcher, A. T. Goldbeck, and Clifford Older. This Committee nominated the following: Messrs. C. D. Curtiss, Arthur N. Johnson, Paul D. Sargent, Frank T. Sheets, and Thomas E. Stanton, Jr. These names were sent out for letter ballot to members of the Division and the results will be canvassed January 18, 1926.

After correspondence with the Local Committee in Montreal, it was decided not to hold a meeting of the Division there at the time of the Fall Meeting of the Society, so only two meetings of the Division were held during 1925.

The first meeting was held in the Auditorium of the Engineering Societies Building in New York, N. Y., January 22, 1925, in connection with the Seventy-second Annual Meeting of the Society. Following the reading of the Annual Report of the Division Secretary, A. N. Johnson, M. Am. Soc. C. E., Dean of the Engineering College, University of Maryland, read a paper on "Elements Governing the Development of Highway Traffic".* This paper was discussed by William H. Connell, M. Am. Soc. C. E., Engineering Executive and Acting Secretary, Pennsylvania Department of Highways; T. R. Agg, M. Am. Soc. C. E., Professor of Highway Engineering, Iowa State College; and Arthur W. Dean, M. Am. Soc. C. E., Chief Engineer, Division of Highways, Massachusetts Department of Public Works. At the afternoon session papers on "Recent Developments in Highway Research" were read by C. N. Conners, Assistant Engineer to the Chief Engineer, North Carolina Highway Department, and H. F. Janda, Assistant Director, Advisory Board on Highway Research, National Research Council. This was followed by a paper on "Effect of Moisture on Concrete"† by William K. Hatt, M. Am. Soc. C. E., Professor of Civil Engineering, Purdue University. This paper was discussed by A. T. Goldbeck, Assoc. M. Am. Soc. C. E., Director, Bureau of Engineering, National Crushed Stone Association. The following resolutions were passed at this meeting:

"*Resolved,* That the Board of Direction be and is hereby requested to appoint a Committee to co-operate with similar committees from the American Institute of Architects, the Associated General Contractors, and the American Association of State Highway Officials in endeavoring to find some solution for existing abuses in the writing of contract bonds."

"*Be It Resolved,* That the Permanent International Association of Road Congresses should be joined by the United States of America; and,

"That such Governmental action as may be necessary to that end should be had as promptly as practicable in order that the United States may be properly represented at the Fifth International Congress to be held in Milan, Italy, in September, 1926."

"*Whereas,* There is a Bill in Congress providing for the re-organization of the Government departments, which in its present form proposes to substi-

* *Proceedings*, Am. Soc. C. E., May, 1925, Papers and Discussions, p. 748.

† *Loc. cit.*, p. 757.

tute a subordinate Division of Public Works within an existing department, for the Department of Public Works endorsed by the Board of Direction of this Society, which proposed division will belittle the position of the engineer in public service rather than give him the recognition he deserves and which was contemplated in the plan for a Department of Public Works; and,

"*Whereas,* Since the proposed transfer of the Bureau of Public Roads of the Department of Agriculture to a subordinate position in the proposed Division of Public Works, and consequent division of its present functions, cannot fail to interfere with the successful co-operative relations with all State highway departments and the continuation of its extensive research work, thus bringing about a condition which highway engineers would deplore; now

"*Therefore, Be It Resolved* that the Highway Division affirms the stand of the Board of Direction for a Department of Public Works and respectfully petitions the Board of Direction to oppose the proposed scheme of re-organization as far as it relates to the engineering agencies of the Government and particularly to oppose the transfer of the Bureau of Public Roads from the Department of Agriculture until a real executive Department of Public Works is provided for."

The sessions were well attended and were presided over by Chairman Shirley.

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C. D. Curtiss,
Secretary, Highway Division.

Annual Report of the Power Division for 1925

The Power Division was organized at the Annual Meeting of the Society in January, 1923, in accordance with the rules laid down by the Board of Direction, for the formation of Technical Divisions. These Divisions have provided opportunity for presentation of papers on subjects of particular interest to those practicing in certain branches, which opportunity could not be given in the general programs of the Society. The programs of the Society have thus been supplemented and the demand for papers on special subjects met in a measure. As evidenced by the large attendances, the meetings of this Division during the past three years have proven of much interest to the engineer concerned with power.

During 1925 the work of the Division has been carried on under the direction of the Executive Committee consisting of: Nathan A. Carle, *Chairman*, Vice-President, Public Service Production Company, Newark, N. J.; Arthur P. Davis, Chief Engineer and General Manager, East Bay Municipal Utility District, Oakland, Calif.; Daniel W. Mead, Consulting Engineer, Madison, Wis.; William W. Tefft, Vice-President and Chief Engineer, Consumers Power Company, Jackson, Mich.; and Charles Rufus Harte, Construction Engineer, The Connecticut Company, New Haven, Conn.

The programs of the Division at the general meetings of the Society during 1925 were:

Annual Meeting, New York, N. Y.—

January 22, 1925, Symposium on High Specific Speed Hydraulic Turbines: Papers were presented by Messrs. George A. Orrok, Lewis F. Moody, Forrest Nagler, George A. Jessop, Charles C. Egbert, and John P. Hogan.

Spring Meeting, Cincinnati, Ohio.—

April 23, 1925, "The Dix River Dam of the Kentucky Hydro-Electric Company," by L. F. Harza, M. Am. Soc. C. E., Consulting Hydro-Electric Engineer and Hydraulic Engineer, Chicago, Ill.; and "Steam Power Plant at Mouth of the Big Miami River," by S. D. Herd, General Manager, Union Gas and Electric Company, Cincinnati, Ohio.

Summer Meeting, Salt Lake City, Utah.—

July 9, 1925, "The Relation of Stream Regulation to Irrigation and Power Development," by J. C. Stevens, M. Am. Soc. C. E., Consulting Hydraulic Engineer, Portland, Ore.

The Symposium on High Specific Speed Hydraulic Turbines has been published by the Society.* The Division is also assured of the publication of Mr. Stevens' paper and it is hoped that others will be published during 1926.

The Executive Committee held no meetings during the year as unfortunately it did not appear possible to fix a date far enough in advance to assure an attending quorum.

The financial statement for 1925 is as follows:

RECEIPTS

Balance on hand from 1924	$505.80
Appropriation by Society	1 200.00
Dues collected, 1925	639.00
Total	$2 344.80

* *Proceedings*, Am. Soc. C. E., August, 1925, Papers and Discussions, p. 999.

DISBURSEMENTS

Executive Committee meetings	0
Division meetings	$252.12
Special Committee work	0
Miscellaneous administration expense	30.42
Unexpended balance of appropriation reverting to Society	917.46
Balance on hand, January 1, 1926	1 144.80
Total	$2 344 80

E. W. MALONEY,
Secretary.

Annual Report of the Executive Committee of the Sanitary Engineering Division for 1925

For the Sanitary Engineering Division, 1925 marked the third full year of existence. The activity of the Division, the interest displayed by its members in the preparation and presentation of papers, and the large attendance at its various sessions, indicate that this Division is filling a need. For this interest, the Executive Committee wishes to express its gratification and appreciation.

The Executive Committee has held two meetings during the Division year ending January 21, 1926, in Cincinnati, Ohio, on April 23, 1925, and in New York, N. Y., on January 20, 1926. At these meetings arrangements for the programs of the Division's sessions, appointments of committees, suitable activities for the Division, and other questions of policy have been studied and determined. Tentative arrangements have been made for consideration at the Kansas City Meeting of the North Side Sewage Treatment Works of the Sanitary District of Chicago, Ill., and at the Philadelphia Meeting of a Symposium on Pollution by Industrial Waste. It now seems wise to omit the Division Session at the Seattle Meeting.

The Division has held three meeting: In New York, on January 22; in Cincinnati, on April 23; and in Montreal, Que., Canada, on October 15, At the time of the meeting on January 22, a joint luncheon was held with the New York Section of the American Water Works Association. Prior to the meeting in January, the Division held its Annual Dinner on January 20.

The programs of papers and discussions have appeared in the *Proceedings* of the Society and are repeated here for convenient reference only.

1925 PROGRAM

Annual Meeting, New York, N. Y.—

January 20, 1925, Annual Dinner at Hotel McAlpin; "The Atmosphere and Its Relations to Human Health and Comfort",* by Professor C.-E. A. Winslow.

January 22, 1925, "Laws Relating to Obnoxious Odors",† by Irving I. Goldsmith, Esq.; "Methods for Determining the Origin, Prevalence and Effect of Obnoxious Odors",‡ by Stephen DeM. Gage, Esq.;

* *Proceedings,* Am. Soc. C. E., May, 1925, Papers and Discussions, p. 794.
† *Loc. cit.,* p. 811.
‡ *Loc. cit.,* p. 820.

"Elimination of Odors from Garbage Disposal Works",* by Samuel A. Greeley, M. Am. Soc. C. E; "Control of Odors from Sewage Treatment Plants",† by John F. Skinner, M. Am. Soc. C. E.; and "The Detection and Elimination of Odors from Oil Refineries",‡ by Robert Spurr Weston, M. Am. Soc. C. E.

Spring Meeting, Cincinnati, Ohio.—

April 23, 1925, Stream Pollution: A Symposium:§ "A Review of the Work of the United States Public Health Service in Investigations of Stream Pollution", by W. H. Frost, M. D.; "The Rate of Deoxygenation of Polluted Waters", by Emery J. Theriault, Esq.; "The Rate of Atmospheric Reaeration of Sewage Polluted Streams", by H. W. Streeter, M. Am. Soc. C. E.; and "Quantitative Studies of Bacterial Pollution and Natural Purification in the Ohio and the Illinois Rivers", by J. K. Hoskins, Esq.

Fall Meeting, Montreal, Que., Canada.—

October 15, 1925, Grit Chamber Practice: A Symposium: "Grit Chamber Design", by George B. Gascoigne, M. Am. Soc. C. E.; "Canadian Grit Chamber Practice", by F. A. Dallyn, Esq.; "British Practice in the Design of Grit Chambers or Detritus Tanks", by Arthur J. Martin, Esq.; and "German Grit Chamber Practice", by Karl Imhoff, M. Am. Soc. C. E.; Illustrated Address on Montreal Water Filtration Plant, by Frederick E. Field, M. Am. Soc. C. E.

Committees

During the year, various Committees were appointed to deal with the following matters: Filtering Material for Sewage and Water Work; Co-Operation with the National Coast Anti-Pollution League; Definitions of Terms Used in Sewerage and Sewage Disposal; Friction of Sludge in Pipes; Co-Operation with New Jersey Agricultural Experiment Station and New Jersey Sewage Works Association; Design of the Rudolph Hering Medal; Nomination; Audit of Books of Division; and Arrangement for January Dinner. As a matter of record, the membership of these Committees is listed as follows:

Committee to Co-Operate with National Coast Anti-Pollution League.—Messrs. C. A. Emerson, Jr., C. M. Saville, and E. S. Rankin.

Committee on Definitions.—Messrs. W. W. Horner, Paul Hansen, and Theodore Horton.

Committee on Friction of Sludge in Pipes.—Messrs. Glenn D. Holmes, Langdon Pearse, and C. E. Keefer.

Committee on Filtering Material for Sewage and Water Work.—Messrs. W. E. Stanley, W. H. Dittoe, and G. B. Gascoigne.

Committee to Co-Operate with New Jersey Agricultural Experiment Station and New Jersey Sewage Works Operators Association.—Mr. C. G. Wigley.

Committee on Design of the Rudolph Hering Medal.—Mr. S. A. Greeley.

Nominating Committee.—Messrs. T. Chalkley Hatton, W. W. Horner, C. E. Keefer, J. L. Ludlow, and R. V. Orbison.

* *Proceedings*, Am. Soc. C. E., May, 1925, Papers and Discussions, p. 832.

† *Loc. cit.*, p. 847.

‡ *Loc. cit.*, p. 854.

§ *Loc. cit.*, November, 1925, Papers and Discussions, p. 1809 *et seq.*

Audit of Books of Division for 1924.—Messrs. Langdon Pearse, W. L. Stevenson, and H. P. Eddy.

January Dinner.—Mr. Kenneth Allen.

FINANCIAL

The budget allowance for the year was $1 200. On December 31, 1925, the end of the fiscal year, a balance of $731.29 remained, which was returned to the Society. A budget allowance of $1 200 has been requested for the ensuing year.

CO-OPERATION WITH OTHER SOCIETIES

In the arrangement of program, your Executive Committee has endeavored informally to co-operate with other Divisions to avoid overlapping and duplication. It is the desire of your Committee that the Sanitary Engineering Division should be distinguished by the excellence of its papers. In this the members must help. The Committee, therefore, requests that those who have suitable material send a memorandum to the Chairman.

INTERNATIONAL CONFERENCE OF SANITARY ENGINEERS

In accordance with the suggestion of 1924, your Executive Committee has considered the question of holding an International Conference of Sanitary Engineers in the United States. After much deliberation by the Committee and inquiry among prominent engineers abroad, it was finally decided to abandon all thought of a Conference in 1926 or 1927, owing to the difficulty of securing any foreign attendance. Further, a reasonable period of time for the art to develop must elapse between such Conferences. It is recommended, therefore, that such Conferences be held at intervals of not less than five years, and that plans be considered at the proper time for a Conference to be held in the United States, probably in 1929. The necessary arrangements can be taken up in 1928.

RUDOLPH HERING MEDAL

It is a pleasure to announce that a design has been made for the Rudolph Hering Medal* and approved by the Board of Direction. The sculptor was Mr. J. F. Brcin, of Chicago, Ill. The medal is to be of bronze, about 3 in. in diameter. The Committee on Design of the Rudolph Hering Medal—Mr. S. A. Greeley—is hereby discharged with thanks for the successful completion of its task.

LANGDON PEARSE, *Chairman,*
H. P. EDDY,
C. H. HURD,
J. C. MCVEA,
W. L. STEVENSON,
Executive Committee.

* *Proceedings*, Am. Soc. C. E., February, 1926, Society Affairs, p. 37.

Annual Report of Executive Committee of the Structural Division

The Structural Division has just completed the first year of its existence. The year has been one of experiment, of endeavor on the part of the Division to find itself, to determine just what its function was in carrying on its part of the work of the Society and just what its relations were with the other Divisions and with the Society as a whole, and to determine in what ways the Division could be of maximum service to its members.

The work of the Executive Committee was hampered at the start of the year owing to the fact that one of the members elected at the last Annual Meeting (1925) was unable to serve and that another member was out of the country and did not return until the year was half over. The three remaining members met and elected Messrs. W. G. Grove, *Chairman,* C. T. Bishop, *Secretary,* and S. C. Hollister to fill the vacancy.

With the ideas brought out at the 1925 organization meeting in mind the Executive Committee circularized the enrolled membership with a questionnaire, the replies to which were of assistance in laying out the program for the year, and offer many suggestions for future work.

The Committee felt that it would be unwise to attempt to hold a technical session during the Annual Convention at Cincinnati, Ohio, but decided to hold the first technical session at the Summer Meeting at Salt Lake City, Utah, in July. This Salt Lake City session proved to be very successful so that the Committee felt encouraged to hold another technical session at the Fall Meeting in Montreal, Que., Canada. In addition to these two meetings, a special meeting was held in New York, N. Y., on October 28, 1925.

The Executive Committee held ten meetings, one in Philadelphia, Pa., and the others in New York, N. Y.

Mr. T. A. Beyer presided at the Salt Lake City Meeting. Papers and discussions were presented at that meeting by Messrs. H. B. Seaman, C. D. Purdon, E. G. Walker, W. E. Belcher, J. O. Draffin, Edward Godfrey, Lee H. Miller, L. H. Tuthill, F. R. McMillan, and J. A Kitts.

Professor W. K. Hatt presided at the Montreal Meeting which was devoted to methods of field control in the production of concrete. Papers were presented by Messrs. R. B. Young, L. H. Tuthill, and F. R. McMillan.

The New York City Meeting was a special meeting on "Unit Stresses in Steel and Other Structural Materials with Special Reference to Building Construction." Chairman Grove presided at that meeting, and papers were presented by Messrs. F. E. Turneaure, A. E. Lindau, D. B. Steinman, and J. A. Newlin, and written discussions by Messrs. H. Cross and E. F. Kenney.

A statement was sent out to the membership under date of October 13, 1925, outlining the activities of the Division to that date.

The Executive Committee has recommended that certain papers presented at the Montreal Meeting and all the papers and discussions at the New York Meeting be printed in the *Proceedings* of the Society. This recommendation is now before the Committee on Technical Activities and Publications of the Society for its approval.

In accordance with the Constitution a Nominating Committee was appointed July 6, 1925, to make nominations for the 1926 Executive Committee. This Nominating Committee, consisting of Messrs. J. B. French, *Chairman*, P. G. Lang, Jr., P. G. Laurson, F. R. McMillan, and G. L. Taylor, made its report and the official ballot was sent to the membership under date of October 2, 1925.

This Executive Committee has considered its greatest duty to be the establishment and extension of the service that should be rendered by the Division to its membership. The Division's purpose is the furtherance of engineering knowledge in the structural field; the provision of means of projecting that knowledge to the membership, and the maintenance of free exchange on all structural matters between the members. To broaden its consideration of policy in this direction, the Executive Committee appointed sub-committees to consider and report on the following lines of Division activity:

(1) Program and Papers, Messrs. W. G. Grove and F. E. Schmitt.
(2) Committee Activities, Messrs. S. C. Hollister, L. J. Towne, and J. J. Yates..
(3) Stimulation of Local Activities, Messrs. C. E. Chase, A. E. Lindau, and C. L. Warwick.

The following recommendations are abstracted from the Sub-Committee reports. The complete reports will be available to the ensuing Executive Committee for its consideration.

Program

The Sub-Committee on Program and Papers recommends that the incoming Executive Committee appoint a Sub-Committee on Program and Papers as early as possible in the current year. This Sub-Committee should consider carefully the geographical field with the idea of holding meetings at places on such structural subjects as are of local interest and related to the engineering problems of those particular localities.

Special effort should be given to securing papers on the present state of the art on structural engineering works and problems on which little engineering literature has recently appeared.

Current literature, foreign as well as American, on recently completed structural engineering works of importance should be presented to the membership of the Division.

A special committee should be appointed to stimulate research along structural lines, working in close connection with any structural development work being done by a research committee of the Parent Society.

As far as possible the Sub-Committee on Program and Papers should enlist the active participation of the younger members of the Division in the preparation and presentation of technical papers.

Stimuation of Local Activities

The success of the Division in bringing the membership into touch with its program and work will be greatly advanced by the development of local

activities. Through such activities the men in districts remote from the principal meeting places of the Society, and the younger men everywhere, should be enabled to take a personal part in its work.

The Sub-Committee believes that it is desirable to have a member of the Structural Division appointed in each locality supporting a Local Section to represent the Structural Division in local affairs and in its relations with the Local Section. This member would keep in touch with the Program Committee of the Section so as to make suggestions for programs on topics of interest to the Structural Division members and would lead in the formation of "round table" groups at the dinner meetings of the Local Sections. These groups would consist of the local members of the Structural Division and they might even have occasional separate meetings for the discussion of Structural Division topics, or when a request has come from the Executive Committee of the Structural Division to secure the local sentiment on debated or timely questions.

Committee Activities

The Sub-Committee on Committee Activities confined its attention to the consideration of:

1.—Existing Special Committees of the Society appointed to act on assignments within the Structural Engineering field.
2.—Relation of Structural Division to Special Committees of the Parent Society.
3.—Relation of this Division to other Divisions on overlapping committee assignments.
4.—Advisability of creating committees within the Division for work on Structural Engineering assignments.
5.—Regulation of Committee activities of the Society.
6.—Desirability and manner of creation of a committee to draft standard specifications for the design and construction of steel buildings.

The Sub-Committee reached the following conclusions as to policy within the Division:

1.—Technical committee activities should be confined to committees created by, and responsible to, the Board of Direction; and the Divisions should refrain from creating, either separately or jointly, committees on technical matters.
2.—It is proper and advisable that the Division through its Executive Committee, present from time to time to the Board of Direction its views and recommendations on the work of existing Special Committees or the formation of new Special Committees working wholly or in part within the Structural Engineering field.
3.—Committees of the Division should be confined to internal administrative matters as directed by the Executive Committee.

The Sub-Committee presents the following recommendations:

1.—That the Board of Direction of the Society be requested to create means of closer contact with, and advisory control over, Technical Divisions, with special reference to assisting them in developing policies commensurate with their needs and in full harmony with regulating and co-ordinating policies of the Board.

2.—That the Division establish the policy of reviewing and discussing in its meetings the reports of the Special Committees of the Society so far as they pertain to the Structural Engineering field.

3.—That the Division express to the Board of Direction or a designated agency of Divisional contact its views concerning the extent of participation of the Division in representation on Special Committees acting in the Structural Engineering field either jointly with other Divisions or Societies, or separately.

4.—That the Board of Direction be requested to appoint a Special Committee on Standard Specifications for the Design and Construction of Steel Buildings, this committee to act jointly with invited committee representation from the American Railway Engineering Association, the American Society for Testing Materials, and the American Institute of Steel Construction. The reasons advanced for the creation of such a committee are as follows:

(*a*) To take advantage of general economics resulting from standardization of requirements and practice.

(*b*) To review and apply in specification from recent advance in practice.

(*c*) To take timely reconsideration of existing specifications and practices in the light of recent developments in unit stresses in structural steel.

The Executive Committee feels that the Constitution should be modified so as to provide for continuity in office of a certain number of the Executive Committee. This year the Nominating Committee provided such continuity, but it is felt that it should be prescribed in the Constitution. An amendment was prepared for action at this meeting, but such action was deferred when it was learned that changes in the Constitutions of all the Technical Divisions are being considered by the Board of Direction which will probably accomplish the same end.

W. G. Grove, *Chairman*,
C. T. Bishop,
C. E. Chase,
S. F. Hollister,
C. F. Loweth,
Executive Committee.

Progress Reports of Committees of Technical Divisions

Progress Report of the Committee of the Sanitary Engineering Division on Filtering Materials for Sewage and Water Work, January 18, 1926

The undersigned were appointed in May, 1925, a Committee on Filtering Materials for Sewerage and Water Work. At the time of the appointment, it was suggested that the Committee consider not only the size of materials, but also their proper preparation and, further, their physical and chemical characteristics with a view to determining the best choice of materials and their suitability for use in both sewage and water work. It was further suggested that it might be well worth while for the Committee to confine its immediate efforts to the study of the physical qualities of materials.

The members of the Committee held a meeting in Chicago, Ill., October 10, 1925, and have considered the subject also by correspondence. The principal efforts of the Committee have been directed toward the gathering of information and data covering filtering materials from which to establish more definitely the need of investigating and to determine the proper scope and program for such an investigation.

In line with the idea of co-operating with the work of other Societies, as suggested in the report of the Executive Committee of the Sanitary Engineering Division for 1924, consideration has been given to the possibility of developing the study of filtering materials for water work in co-operation with the American Water Works Association. At the present time there is no committee of the American Water Works Association the duties of which cover the general field of filtering materials. There is, however, a Committee on Filter Sand Testing and Recording, which is charged primarily with maintaining watch over the developments and experiences in the use of filter sand in water purification filters.

Perhaps the logical course would be to leave to the American Water Works Association the responsibility for determining the need of, and the initiation of, detailed investigations with reference to filtering materials for use in water treatment plants, and for this Committee to apply its efforts primarily to the study of materials for use as filtering media in sewage work. However, since the activities of the members of the Sanitary Engineering Division include both sewage and water work, any committee of the Sanitary Engineering Division on filtering materials should co-ordinate investigations covering both sewage and water work.

The need of standard methods for determining the relative merits of various materials for sewage filters and the proper choice of such material for use has not been pronounced until recently. Many of the existing plants are relatively small, or else the larger plants are located in regions where filter material is plentiful and of a fairly good quality. There are exceptions to this, of course. The general practice in the past has been to select the filter media, especially for trickling filters, for the most part in such a way as to

secure the material from the nearest source, provided it appeared hard and durable. For example, the Columbus, Ohio, filters are filled with limestone; those at Reading, Pa., with slag; those at Plainfield, N. J., with trap-rock obtained locally; those at Fitchburg, Mass., with granite obtained locally and trap-rock shipped in from a short distance; those at Marion, Ohio; Schenectady and Gloversville, N. Y.; Decatur, Urbana, Elgin, and Chicago, Ill., with limestone obtained locally or shipped short distances. One exception to this rule is the recent installation of trickling filters at Lincoln Nebr., where it was decided to use quartzite shipped from a considerable distance and at a higher price instead of the local limestone, as the local limestone was decided to be unsuitable after a series of freezing tests had been conducted.

The past few years have witnessed rapid increases in both number and size of new installations of sewage and water plants, which require considerable quantities of material for filter media. Also, there has been an increasing number of plants where the filter media has deteriorated or is showing indications of trouble, particularly in the central section of the United States. At the same time the demand for public improvements of all sorts has taxed the financial resources of many communities to such an extent that it behooves engineers to do everything possible in order to insure that all phases of new work are developed in the most economical manner possible.

The factors which control the selection of materials for filter media vary in different sections of the country. However, there are many phases of the problem which are common to all sections although the relative weight to be given each phase may vary. Accordingly, a well-developed investigation should be of general value.

A comprehensive investigation naturally separates into three general divisions, as follows:

1.—Physical or qualitative properties of materials. Kinds of materials, physical and chemical characteristics, durability, proper sizes, preparation, methods of testing and selecting, relative merits of various grades of materials.

2.—Quantities of materials. Loadings, depth of beds, thickness of layers, etc.

3.—Design details as affected by type of filtering material to be used, such as possible modifications in filter under-drains, depending on kind and size of filter media.

The present principal need with reference to the selection of filter materials seems to be for methods and standards or specifications by which to determine and compare the relative merits and suitability of various kinds and grades of materials for use as filter media in specific installations. In view of this it would appear that present and near future investigations might better be carried on with particular reference to the first division of study as given previously. Furthermore, it seems advisable to confine the research efforts for the present, to the detail study of the coarse-grained materials, particularly to materials which may be used as filtering media in trickling filters or contact filters in sewage treatment work. Later, the detail studies should be extended to include fine-grained materials and perhaps also materials for use in water work.

The work of the Committee in progress at present can be briefly outlined, as follows:

I.—General Phases of the Problem.—

(*a*) Review of literature.
(*b*) Need for investigations.
(*c*) Possibility of co-operation with other investigations along similar or allied lines.
(*d*) Program of investigations.

II.—Experience Data from Existing Plants.—

(*a*) Lists of existing trickling and contact filter plants by States.
(*b*) Materials used and troubles experienced.
(*c*) Length of time in service.

III.—Methods for Selecting and Testing Filtering Materials.—

(*a*) Methods used during the past.
(*b*) Proposed chemical and physical analyses and soundness tests.
(*c*) Series of laboratory tests to verify value of proposed tests and analyses.

The Engineering Societies Library has furnished a general list of references covering the use of filtering materials back to about 1890. This has been taken as the basis for a general review of the technical literature. There appears to be very little published data with reference to filtering materials from the point of view of the proper selection of materials with regard to their comparative durability and economic aspects.

Letters have been exchanged with various Governmental bureaus, research societies, and other organizations and also individuals who might be interested in the work of the Committee. These indicate that there is a considerable interest in studies of filtering materials from the standpoint of relative durability and comparative cost.

In considering a program of investigation, it is believed that experience with materials in existing plants should form the foundation upon which to base such outline of general study. Accordingly a letter of inquiry has been sent out to each State sanitary engineer, or other State officer performing sanitary engineering duties, together with form blanks for listing the trickling filters and contact filters in each State, with pertinent data in regard to the filter media in each installation. The number of replies from this inquiry received to date have not been sufficient to make it worth while to attempt a tabulation of the results. It is expected to follow up the inquiry with letters to the designing engineers and plant operators where necessary, so that complete data will be obtained regarding the principal installations over the country, particularly with reference to any difficulties experienced with the deterioration of the filter media.

It is planned to apply chemical and physical analyses and soundness tests to samples of the filtering media taken from a number of selected filter installations in an endeavor to develop some program of tests which will allow of the classifications of various types and grades of materials with regard to their relative merits for use as filter media.

There are, perhaps, two principal agencies which tend toward the destruction of filter media, namely, the breaking up of the material by mechanical weathering and the reduction of the material by chemical solution.

The first agency has to be considered in connection with materials for road building in which connection quite a variety of tests has been developed to indicate the relative value of such materials. It is possible that many of these tests will be of value in testing materials for filter media. Most of these tests have to do with the structural properties of materials.

The second agency, that of chemical solution, is related to the chemical composition of the material and also to the chemical composition of sewages. It seems likely that analyses to determine the chemical constituents of filter materials would give data of value.

It would seem advisable to include in a comprehensive series of analyses of filter media any tests if there is a possibility that the results obtained from such tests may be of value. After sufficient data have been collected it likely will be possible to reduce the number of tests and simplify the procedure.

The Committee would be glad if members of the Society would send the Chairman any suggestions they have as to the carrying on of the investigations of filtering materials and also any data they have concerning methods of selecting and testing materials for use as filter media.

The Committee at present consists of three members, two from Ohio and one from Illinois. There are many advantages to a committee of three, but the questions which arise in connection with filtering materials assume different aspects in different sections of the country, so it might be advisable to increase the membership to five and appoint a member from the East and one from the South Central West, in order to get a wider geographical distribution of Committee members.

Respectfully submitted,

William E. Stanley, *Chairman*,
W. H. Dittoe,
George B. Gascoigne.

APPENDIX I

Letter of Inquiry and Data Sheet on Filtering Materials Sent to Each State Sanitary Engineer for Information with Reference to Trickling and Contact Filters

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Sanitary Engineering Division
American Society of Civil Engineers
Committee on Filtering Materials for Sewage and Water Work

Columbus, Ohio, December 9, 1925.

Dear Sir:

This letter is being addressed to each State sanitary engineer or other State officer performing sanitary engineering duties.

The American Society of Civil Engineers has appointed a Committee on Filtering Materials for Sewage and Water Work, comprising Wm. E. Stanley, Chairman, Geo. B. Gascoigne, and W. H. Dittoe. After giving general consideration of the program of work of the Committee, it has been decided to undertake first the question of filtering media for coarse-grain sewage filters, namely, trickling filters and contact filters. One of the most important phases of this question relates to the permanency of the material used, or in other words, its resistance to disintegration. The Committee desires as a first step to obtain information relative to existing municipal trickling filter plants and contact filter plants in the United States. The writer has been assigned the duty of securing this information and I am taking the liberty of sending you a number of blank forms on which it is requested that you record the desired information for the municipal plants of your State as completely as possible. A sufficient number of forms will be furnished to you to permit use of four copies for each plant in your State, an original copy and three carbon copies, and it is requested that three copies be returned to me leaving one copy for your record. In case you need additional forms please advise me.

The following explanation of the items appearing on the form may be of assistance:

1.—This item is to be answered: (*a*) Imhoff tanks: trickling filters; (*b*) septic tanks: contact filters, etc., as the case may be.

2.—Self-explanatory.

3.—Give year of installation of plant and if filtering material was subsequently replaced give date of replacement and information pertaining to same under Items 11 to 15, inclusive.

4.—Self-explanatory.

5.—Self-explanatory.

6.—Self-explanatory.

7.—Give name and address of designing engineer or consulting engineer or other engineer in charge of construction as the Committee may desire to obtain data from him.

8.—Give name and address of the plant operator or other official in charge of the plant.

9.—Give total area, in acres.

10.—Self-explanatory.

11.—State whether trap-rock, limestone, slag, gravel, cinders, or other material.

12.—This refers to sizes of the material as placed. If in layers, describe. Give shape of particles particularly if flat.

13.—This refers to location of the source such as the quarry from which obtained, distance from plant, and also refers to the geological formation.

14.—Give cost in place if possible. If not, cost at source or on job and so state.

15.—It is desired that information be furnished to indicate whether the selection was based on considerations of cost, availability, or quality of material. The Committee is particularly desirous of learning whether quality considerations played an important part in the selection, and if so, what particular qualities were considered. If specifications of quality were used a copy of the same would be of assistance.

16.—Tests to determine fitness of material before selection.

17.—If disintegration of material has been noted give approximate date when first observed, state whether temporary or continuous. Give nature and seriousness and probable cause if possible.

19.—If filters are operated throughout the winter and no freezing occurs so state.

20.—You probably may be unable to furnish all information from your available records. Please answer such items as you can and give names and addresses of consulting engineer or municipal officials from whom the information may be obtained.

Prompt return of the information will be much appreciated by the Committee in order that a progress report may be made at an early date.

Thanking you for your co-operation in this matter, I am

Yours truly,

W. H. Dittoe,

***Chief Engineer*, Ohio Dept. of Health, Columbus, Ohio.**

Sanitary Engineering Division

American Society of Civil Engineers

Committee on Filtering Materials for Sewage and Water Work

Data Regarding Filtering Materials for Trickling Filters and Contact Filters

1.—Type of plant..
2.—Municipality served.............................State...............
3.—Year of installation..
4.—Population designed for...
5.—Population served 1925..
6.—Sewage filtered 1925 (M. G. D.)....................................
7.—Designing engineer..
8.—Plant operator...
9.—Total area of filters..
10.—Depth of filtering material.......................................
11.—Kind of filtering material..
12.—Range of size...
13.—Source of material..
14.—Cost of material placed...................cu. yd...................ton
15.—Reasons for selection...
...
16.—What tests if any were made.......................................
17.—Disintegration noted..
...
18.—Clogging noted..
...
19.—Are filters operated during freezing weather?.....................
20.—From whom above information may be obtained.......................

Information furnished by..

(Title) ....
(Address) ....
(Date) ....

Progress Reports of Special Committees of the Society

Progress Report of Special Committee on Flood Protection Data*

To the Board of Direction,
American Society of Civil Engineers:

A meeting of the Special Committee on Flood Protection Data was held at Society Headquarters, in New York, N. Y., January 15, 1925, and members have conferred informally with respect to the Committee's work at other times as opportunities have offered. The work of compiling data concerning floods on the forms previously adopted† has been continued.

Following the recommendations contained in the report of the Committee for 1924,‡ the President and the Secretary of the Society have discussed with George Otis Smith, Director of the U. S. Geological Survey, the advisability and possibility of obtaining Federal assistance in the study of floods. As a result of this discussion, Dr. Smith will include in his estimates for the fiscal year 1927 an item for this work. This item cannot come before Congress for consideration, however, until it has been favorably passed by the Bureau of the Budget and the Appropriation Committees. It is uncertain, therefore, whether funds can be obtained in the near future from that source.

The recognition by the Board of Direction of the value of the Committee's work and of its need for funds has encouraged the Committee to seek funds elsewhere. Other possible sources of financial assistance have therefore been approached, but so far without success. Efforts will be continued, however, until funds are available for continuing the work on a larger scale than is possible by means of volunteer assistance.

Flood data are unfortunately in a chaotic state. The Committee concurs in a belief of the Board of Direction that the clarifying and systematizing of flood problems constitute a service that the Engineering Profession owes to the public. As the work of the Committee has progressed, its importance and value have become more and more evident.

The use of water is rapidly increasing. The unchecked growth in the production of power, the increase in industries, and the extension of towns and cities have led to the building of many structures in the channels of rivers and in valley bottoms. These developments are continuing and will continue until many of our rivers are fully utilized.

The damages caused by floods are increasing because more property is being placed where it is exposed to flood dangers. This increase in damage has led to a widespread belief that floods are increasing in frequency and magnitude. Except under special conditions, however, the statistical data available indicate no positive changes in rainfall and run-off, or in frequency or magnitude of floods.

* Presented to the Annual Meeting, January 20, 1926.

† *Proceedings*, Am. Soc. C. E., August, 1925, Papers and Discussions, p. 1138.

‡ *Loc. cit.*, March, 1925, Society Affairs, p. 135.

Engineers must continue to design and erect structures in and near rivers and must make such estimates as are possible of flood expectancy, stages, and magnitude. The collection and analysis of flood data is so great a task, however, as to be prohibitive to an individual or organization of ordinary resources. The value of the work to a single project may easily exceed the entire cost of the Committee's proposed investigations. An adequate compilation and analysis of flood data would be of inestimable value to engineers and would add to the wealth of the nation many times the cost of the work.

Flood data serve two important needs of engineers: Records of stage are used in establishing elevations of buildings of all kinds and of grades of highways and railroads, and records of discharge are used in the design of dams and other structures which should have sufficient capacity for the flow at all stages.

The valuable paper presented by C. S. Jarvis, M. Am. Soc. C. E., entitled "Flood Flow Characteristics,"* and the discussions thereon have served to emphasize the importance of flood problems in their relation to the work of engineers. In these discussions many significant and valuable suggestions have been made relative to the phases of floods that are most important and to the nature of the flood data needed by engineers. The discussions have also disclosed differences of opinion among engineers as to the best methods of analyzing and publishing flood data. The Committee favors the probability method of study and the diagrammatic form of publication, and as funds become available its efforts will be thus directed. Many factors affect floods, but the principal factors, precipitation and temperature, although governed by principles not yet fully known, have been found to follow closely the law of probability. The probability method of study has therefore yielded valuable results in estimating the periodicity of floods of various magnitudes. The diagrammatic form of presentation is favored because of its clearness and conciseness of expression and the relatively small cost at which the data can be published, and because the diagrams will convey to engineers who use them not only the conclusions of the Committee, but the data on which those conclusions have been based. The supporting facts will also indicate the limits within which the diagrams may be safely used.

The continuation of the Committee with increased efforts to obtain adequate financing for it on the basis of the 1924 report is respectfully recommended.

N. C. GROVER, *Chairman*
C. B. BURDICK,
W. P. CREAGER,
HARRISON P. EDDY,
GERARD H. MATTHES,
CHARLES H. PAUL,
A. O. RIDGWAY.

October 5, 1925.

* *Proceedings*, Am. Soc. C. E., December, 1924, Papers and Discussions, p. 1553.

Progress Report of the Special Committee on Concrete and Reinforced Concrete Arches*

To the Board of Direction,

American Society of Civil Engineers:

The Special Committee on Concrete and Reinforced Concrete Arches begs leave to submit the following report of progress.

Attention is called to the two previous Progress Reports of the Committee, for the years 1923† and 1924,‡ and at the risk of repetition the Committee wishes to review, briefly, the work of the past three years.

The Committee was appointed in May, 1923, and held its organization meeting on June 25, 1923. At this meeting a survey of the problem resulted in selecting the effect of construction procedure and climatic changes upon the stresses in arches, as the topics for immediate study. The Committee succeeded in interesting the Ohio State Highway Department and the University of Illinois Engineering Experiment Station in this subject sufficiently for them to provide the facilities and funds necessary for the investigation of these subjects at two bridges, one at that time under construction at Conneaut, Ohio, and the other in service at Danville, Ill.

Conneaut Bridge

A description of the bridge at Conneaut, Ohio, and a diagram (Fig. 1) giving its general dimensions, were printed in the Progress Report of the Committee for 1923, referred to previously. Clyde T. Morris, M. Am. Soc. C. E., Professor of Civil Engineering, Ohio State University, Chairman of the Committee, is now preparing a complete report of the investigations made at Conneaut, for presentation to the Society. Briefly summarized, these investigations included:

1.—Measurement of the yielding of the foundations under both sides of one pier.

2.—Strain-gauge measurement of the deformations around the crown and springing line and along the neutral axis of two adjacent spans.

3.—Internal temperature readings at five points near each springing line and five points at the crown of each span.

4.—A duplicate of the crown section of the arch rib, 6 ft. long, was cast at the same time the arch was poured, on supports near the ground, and all measurements and readings on the crown section were repeated on the test specimen which is free from stresses due to arch action.

The bridge at Conneaut was completed and opened for traffic on July 18, 1924. After completion, the Committee arranged to have the observations on the bridge continued for a period of one year, or until September 1, 1925.

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* Presented to the Annual Meeting, January 20, 1926.

† *Proceedings*, Am. Soc. C. E., March, 1924, Society Affairs, p. 290.

‡ *Loc. cit.*, March, 1925, Society Affairs, p. 129.

The observations on the test block mentioned in Item 4, seem to indicate that the expansion and contraction due to climatic changes are less than is ordinarily assumed in arch calculations. A laboratory investigation of this subject has been started at the Engineering Experiment Station, University of Illinois, and observations of the effect of climatic changes are being carried on at two other bridges.

The investigation at Conneaut was under the general supervision of Professor Morris, and the observations during construction were in immediate charge of J. R. Burkey, Resident Engineer for the State.

The Committee is indebted to the Ohio State Highway Department, George F. Schlesinger, M. Am. Soc. C. E., Director of Highways and Public Works, to J. R. Burkey, Chief Engineer of Bridges, and to the Pitt Construction Company, Contractors, for their assistance and co-operation in the work done at Conneaut.

Danville Bridge

The extended series of observations to determine the effect of climatic changes on the behavior of the six-span Gilbert Street Bridge at Danville, Ill., described in the Progress Report for 1924, previously mentioned, has been completed. Observations were begun in November, 1923, and finished in June, 1925, having been made at intervals of approximately a month for this entire period. A report is being prepared for publication, by W. M. Wilson, M. Am. Soc. C. E., Research Professor of Structural Engineering, University of Illinois, in which the observations will be described and the results will be presented and analyzed in detail.

The observations are very complete, and the data on the whole are proving to be very consistent. No detail data are presented in this report, but certain tendencies in the behavior of the structure warrant special mention.

The behavior of the expansion joints in the deck is of interest from the standpoint of the practical design and construction of arches. Each of the four longest spans was provided with four expansion joints, one at each end adjacent to the piers and one at each side of the saddle near the crown. The movement in the joints near the piers was, in general, quite large, whereas that in the joints adjacent to the saddle was uniformly very small. If these observations are supported by others now being made on other bridges, it would seem logical to omit the inactive joints.

Another observation of academic interest and possibly of practical importance in the design of arches, was the rotation of some of the piers accompanying changes in temperature and due, probably, to the unbalanced temperature thrusts of the unequal spans adjacent to a pier. The rotation was small but consistent and indicated a possibility of the temperature strains in one span being accentuated by the temperature thrust from an adjacent span. Temperatures in the arch rib were measured at a point 3 in. from the surface and at the center of the section, the average of the two readings being taken as the average temperature of the arch rib. The lowest observed average temperature (in January, 1924) was $+14°$ Fahr.; the highest average (in August, 1924) was

+ 75° Fahr.; the lowest reading (in December, 1924) was + 6° Fahr.; and the highest reading (in June, 1925) was 89° Fahr. The maximum observed range in the average temperature was, therefore, 83° Fahr. The maximum variation that occurred was probably 10° greater, as neither the highest nor the lowest air temperatures occurred on the days on which observations were made.

Strain-gauge readings were taken on the concrete at the surface parallel and normal to the axis of the arch rib. The deformation in a transverse direction has been ascribed to changes in temperature and in the moisture content. The difference between the two deformations, one on a transverse gauge line and the other on a longitudinal gauge line has been ascribed to a change in the stress. On this basis, the maximum range in the unit deformation due to stresses was somewhat in excess of 0.0002 in. per in. If this deformation is due to stress, and if the stress is computed on the basis that E is constant and equal to 2 000 000 lb. per sq. in., the unit stress variation due to seasonal changes is somewhat in excess of 400 lb. per sq. in. If flow of the concrete takes place the stress is correspondingly reduced.

The work on the Danville Bridge has been done by Professor Wilson and his research assistants of the Engineering Experiment Station of the University of Illinois. The cash expenditures have been made from funds provided by the Society.

Pier Movements

In the measurements taken at Conneaut and Danville, evidences of very definite movements of the piers have been observed. Both these bridges are founded on rock and the small movements observed probably have little effect on the stresses, but the pier movements of bridges on less secure foundations must be of much greater magnitude, and the Committee, therefore, has distributed instruments for detecting pier tipping, to engineers in various parts of the country who are willing to co-operate in making observations.

Readings are now being taken periodically to determine the movements of piers and abutments in the following bridges.

1.—Davis Street Bridge, Topeka, Kans.—This structure is a three-span highway bridge, about 150 ft. long, consisting of narrow, spandrel-filled arch ribs, with extra width of roadway and sidewalk supported on cantilever brackets. It was built in 1924 and observations were begun during construction. The piers and abutments are supported on piling.

2.—Bridge in Neosho County, Kansas.—This structure is a 75-ft. single-span highway bridge having a narrow, spandrel-filled arch rib, with extra width of roadway supported on cantilever brackets. The structure was built during the autumn of 1924 and placed in service some time during the following winter. Observations were begun after the side forms were removed, but before the centers were struck. The structure is founded on a rather hard shale rock at a comparatively shallow depth below the springing plane.

3.—Bridge in Jefferson County, Kansas.—This structure is a single-span highway bridge of the through arch type, 130 ft. long, built in 1923. The struc-

ture rests on a pile foundation. Observations were started on this structure in December, 1924.

The observations on these three bridges in Kansas are being taken under the general supervision of John R. Chamberlin,* Assoc. M. Am. Soc. C. E., Senior Highway Bridge Engineer, U. S. Bureau of Public Roads, by Messrs. Seth Kingman and Sam Elliott, of the Kansas State Highway Department, and Lloyd B. Smith, M. Am. Soc. C. E., Chief Engineer, Topeka Bridge and Construction Company. The Committee is indebted to these men for their aid and co-operation.

4.—Washington Street Bridge, Rockton, Ill.—The Washington Street Bridge at Rockton, Ill., was begun in the summer of 1925 and is still under construction. It is an open-spandrel, two-rib, right arch, consisting of eight spans each 65 ft. long. Three piers and one abutment are founded on rock and four piers and the other abutment are founded on piles.

Observations were begun as soon as the first pier was poured and readings have been taken after each stage in the construction has been completed. The channel contains water under the entire bridge, making observations difficult. For this reason, observations during the early stages of construction were limited to rotation of the piers and abutments about horizontal axes normal to the center line of the bridge. A plan has now been devised whereby it is hoped that horizontal and vertical movements of the piers may be observed while the remaining portion of the bridge is being built.

The observations are being made without charge to the Society by James F. Goldsberry, Resident Engineer for the Illinois State Highway Department, working under the direction of Professor Wilson.

5.—Clark's Ferry Bridge, Harrisburg, Pa.—This structure is a multiple-arch bridge, about ⅜ mile long, over the Susquehanna River. The spans are about 140 ft. long and the piers are founded on rock in shallow water. Observations as to pier movements were made during construction by Frank M. Masters, M. Am. Soc. C. E., Consulting Engineer, Harrisburg, Pa. Small rotations of all piers, including the abutment piers, in direction, in agreement with changes in load conditions during construction, were observed by the use of the special precise level-bar provided by the Committee.

6.—Bridge, Piqua, Ohio.—There is now being constructed at Piqua, Ohio, a five-span, through, reinforced concrete arch bridge, about 450 ft. long. The two abutments and one pier are completed. Arrangements have been made with the Ohio State Highway Department, to have observations of pier movements taken during the construction. The observations will be made by Richard Orth, Resident Engineer, under the general supervision of Professor Morris.

7.—Agler Bridge, Columbus, Ohio.—This is a seven-span, two-rib, open-spandrel, reinforced concrete arch bridge, about 700 ft. long, built in 1916. The piers and abutments are founded on piles. The flood-plane on the two sides of the stream is practically level and is covered only at times of extreme high water, so that all the piers are easily accessible. The stream proper flows

* Mr. Chamberlin died December 15, 1925.

under the middle span. Points have been set on all the piers, for taking level-bar readings to determine pier tipping. Points have also been set for keeping careful record of changes of span length and rise and fall of the crowns of the arches. This work is just being started under the direction of Professor Morris, by the Engineering Experiment Station of the Ohio State University.

8.—Oliver Avenue Bridge, Indianapolis, Ind.—The Oliver Avenue Bridge, at Indianapolis, Ind., was built during 1925. It is a spandrel-filled barrel arch, about 60 ft. wide, and consists of five spans approximately 130 ft. long. The piers and abutments are founded on piles driven into gravel. The arches are skewed, the piers making an angle of 83° 4′ with the center line of the bridge.

Observations were made to determine the movements of the piers due to the various construction processes. A number of barrels had been poured before arrangements could be completed for making the observations so that the record is not complete; however, observations have been made to determine the effect of pouring some of the barrels, of removing the shores, and of adding the fill and the deck for a number of spans.

The movements observed include the horizontal and vertical displacement of the piers and their rotation about a vertical axis and about a horizontal axis parallel to the piers. Observations were also made to determine the vertical movement of the crown of a number of spans.

The bridge was completed in the fall of 1925, but observations will be continued during the winter to determine the movement of the piers due to climatic changes.

9.—Kentucky Avenue Bridge, Indianapolis, Ind.—The Kentucky Avenue Bridge, at Indianapolis, Ind., was built during 1925. It is a spandrel-filled barrel arch about 60 ft. wide and consists of seven spans approximately 130 ft. long. The piers and abutments are founded on piles driven into gravel. The arches are skewed, the piers making an angle of 43° 08′ with the center line of the bridge.

Observations were made to determine the movements of the piers due to the various construction processes. Part of the bridge had been poured before arrangements for making observations had been completed; however, observations have been made on three piers to determine the effect of pouring the adjacent barrels, and on four piers and two abutments to determine the effect of removing the shores and adding the fill and the deck.

The movements observed include the horizontal and vertical displacement of the piers and their rotation about a vertical axis and about a horizontal axis parallel to the piers. Observations were also made to determine the vertical movement of the crown of a number of spans.

The bridge was completed in the fall of 1925, but observations will be continued during the winter to determine the movement of the piers due to climatic changes.

The observations on these two bridges in Indianapolis, are being made by the engineer hired from funds provided by the Society, working under the supervision of Professor Wilson. The contractors have greatly facilitated the work of the Committee by co-operating with the observer and they have done

all the special construction work incident to the observations without charge.

The Committee is indebted to the following firms and persons for their aid and co-operation in the work being done on the two bridges in Indianapolis: Frank C. Lingenfelter, City Engineer, and Russel H. Peters, Inspector for the City of Indianapolis; Daniel B. Luten, Consulting Engineer, designer of the two bridges; The Mead-Balch Construction Company, F. R. Mead, President, John Balch, Vice-President, and Otis Manbury, Superintendent; The Stein Construction Company, R. B. Peters, Superintendent, and W. C. Benton, Engineer.

Skew Arches

At the second meeting of the Committee in Conneaut, Ohio, in September, 1923, an investigation of the possibility of a mathematical analysis of the stresses in skew arches was discussed, and the topic was assigned to E. H. Harder, Assoc. M. Am. Soc. C. E., a member of the Committee, for study and report. Shortly thereafter the paper of J. Charles Rathbun, M. Am. Soc. C. E., entitled "Analysis of the Stresses in the Ring of a Concrete Skew Arch",* was published and Mr. Harder presented a discussion of Professor Rathbun's paper which has also been published.†

The Committee, believing that experimental data were necessary before a satisfactory working theory could be developed, requested George E. Beggs, M. Am. Soc. C. E., Associate Professor of Civil Engineering, Princeton University, to study the problem of experimental investigation of the subject by means of models, similar to his method for simple arches. After an extensive study of materials suitable for models, hard rubber was selected, and two models have been cast and are now in Professor Beggs' laboratory. The result of the measurements now being taken for the Committee on the Kentucky Avenue Bridge, in Indianapolis, also may shed some light on this subject, as the bridge is a barrel arch which is skewed more than 45° and rests on pile foundations. At the time of the meeting of the Committee in Washington, D. C., in September, 1924, the members visited the laboratory of the United States Bureau of Public Roads, where laboratory experiments on reinforced concrete skew arch models were being carried on. From these various sources, it is hoped that a satisfactory method of design may be evolved.

Theoretical Investigations

In order to carry on its work the Committee was also obliged to include in its researches, the theoretical development of arches. With this in mind, A. C. Janni, M. Am. Soc. C. E., wrote his paper, "The Design of a Multiple-Arch System and Permissible Simplifications."‡ For the purpose of analysis and to show clearly the effect of the elastic deformations of thin high piers on multiple-arch spans, Mr. Janni selected a system of three flat arch spans, of 50 ft. each, with a rise of 5 ft., supported on two piers, 40 ft. high and 1 ft. 4 in. wide at the top. The outer ends of this system are assumed to be rigidly fixed. The influence lines were developed by means of the ellipse of elasticity

* *Transactions*, Am. Soc. C. E., Vol. LXXXVII (1924), p. 611.

† *Loc. cit.*, p. 660.

‡ *Transactions*, Am. Soc. C. E., Vol. 88 (1925), p. 1142.

and show the effect of the loaded span on the adjacent and unloaded ones. This paper provoked interesting discussion. Professor Beggs showed that the same results which were obtained by Mr. Janni, could be obtained by measuring the deformations induced in a celluloid model, and illustrated this by showing motion pictures of a train of loads passing over a model of the system designed by Mr. Janni for his paper.

The Committee has also given the skew arch some attention, as noted, both in the field and from the theoretical viewpoint. Because of the highly complex nature of the stresses in this type of arch, little attention has previously been given to its theoretical development either in the United States or abroad. Mr. Harder spent considerable time on this subject for the Committee, but was preceded in the publication of his results by Professor Rathbun, who presented his paper entitled "Analysis of the Stresses in the Ring of a Concrete Skew Arch," previously mentioned, early in 1924. As stated, Mr. Harder participated in the discussion of this paper and presented the theory he had developed. Although Professor Rathbun's analysis was wholly analytical, and that of Mr. Harder was largely graphical, they led to the same results. Mr. Harder, however, challenged the correctness of the assumptions on which both methods were based and, at this time, the Committee feels that much work will be necessary to put the skew arch on a firm theoretical foundation.

Another interesting paper on the geometry of the concrete arch is that of Charles S. Whitney, M. Am. Soc. C. E., entitled "Design of Symmetrical Concrete Arches."* In this paper, Mr. Whitney gives, for the first time in the English language, the results of theoretical researches conducted over a long period of time by various German engineers. He gives the development of a formula by which the axis of a reinforced concrete arch may be plotted and also states the law of the variation of the depths of the rib, as developed by Ritter and others. Knowing the mathematical formula for the shape of the arch and the mathematical variation of the moments of inertia throughout the arch, it is not difficult to evaluate the various integrals which have, by other methods, been compiled by summation. Mr. Whitney's paper is an important contribution to the literature on the subject. Although this paper was not inspired by the Committee, it welcomes it and hopes that others may follow the lead of Messrs. Whitney and Rathbun and present to the membership of the Society such theoretical and practical methods as they may have developed in practice. In this way, the members of the Society will not only assist the work of the Committee, but will benefit the entire profession.

Laboratory Investigations

As noted in the report of the Committee for 1924, tests have been started at the Engineering Experiment Station of the University of Illinois, to determine the effect of the slenderness ratio on the strength of arch ribs without lateral support. The object of the first series of tests was to determine the unit breaking strength of a reinforced concrete arch and the effect of the slenderness ratio of the rib upon this strength. Four arches have been built

* *Transactions*, Am. Soc. C. E., Vol. 88 (1925), p. 931.

and tested. These arches had a span of 19 ft. 3 in., a rise of 4 ft. 6 in., and a thickness at the crown of 4 in. They were tested in a testing machine, and were loaded at six points in such a way that the thrust line fell inside the middle-third over the entire length of the arch. The arches were identical in profile, and they all contained the same percentage of reinforcing steel at the crown, the width of the arches being the only conscious variable. The widths used were 16, 12¼, 9, and 4 in., respectively, making the ratio of unsupported length to width, 15.40, 18.86, 25.67 and 57.75, respectively. The results of the tests have not been analyzed as yet, but an inspection of the data indicates that the unit stress at failure was not greatly affected by the slenderness ratio within the limits used and that the unit stresses at failure agreed roughly with the crushing strength of 6 by 12-in. control cylinders.

The most striking phenomenon in connection with the laboratory tests was the abruptness with which failure occurred. The 9-in. arch was carefully examined when subjected to a load of 170 000 lb. and no cracks or other signs of impending failure could be detected, yet at a load of 177 000 lb. the arch suddenly collapsed with a loud report. Likewise, the 16-in. arch was examined at a load of 270 000 lb. and no sign of failure was apparent. The load was then increased to 300 000 lb. and held at that point for about 5 min. and then, without warning, the arch collapsed with the abruptness of an explosion.

The tests to determine the effect of the slenderness ratio will be repeated for the first part of the 1925-26 program. The arches will have a span of 17 ft. 6 in., a rise of 4 ft., and a thickness at the crown of 5 in. The width of the ribs will be 8, 6, 4, and 3 in., respectively.

Further work during 1925-26 will include tests to determine the effect of spiral reinforcement at the weak section, on the unit load at failure, and also on the margin between the load producing visible evidence of impending failure and the maximum load that the arch can carry.

As noted in its report for 1923, the "flow" or time yield of concrete under stress was recognized by the Committee as of considerable importance in its effect on the stresses in concrete arches and the Committee is pleased to note that the Committee on Arch Dam Investigation of Engineering Foundation is taking up this problem in some detail. The Committee has also been informed that other researches in this field are being conducted by J. R. Shank, M. Am. Soc. C. E., Professor of Structural Engineering, Ohio State University, and it is hoped that the results of these various studies, together with those carried on by others in the past, will furnish the Committee with material for the determination of the effect of the time yield on the stresses in concrete arches.

Forecast of Work Still to Be Done

The Committee presents a statement of the work which it deems necessary before a final report is made to the Society as follows:

1.—A complete report of the work done at Danville and Conneaut with an analysis of the results obtained.

2.—A comprehensive analysis of the measurements being made of pier movements and a study of their effect on the stresses in arches. In this con-

nection, laboratory tests have been planned to determine the movements of the abutments, both rotational and longitudinal, necessary to cause the failure of arches when the load carried is one that would be safe for a similar arch having fixed abutments.

3.—A comprehensive summary and analysis of the various investigations of skew arches, both experimental and theoretical. The Committee hopes to be able to present a satisfactory and practical solution of the problem.

4.—A safe and economical theory upon which to base the design of through arch ribs. The through arch bridge which is coming more and more into use as a substitute for steel bridges of less than 150-ft. span, is limited by the usually accepted ratio of unsupported length to width of rib. The Committee hopes that the laboratory tests supplemented by field observations on bridges in service, will throw some light upon this subject.

5.—A summary of existing knowledge concerning stresses in concrete arch bridges due to seasonal changes. This will include the laboratory and field investigations now in progress and a study of the effect of time yield upon these stresses.

6.—A study of the effect of time yield of concrete upon dead load stresses and stresses due to climatic changes.

7.—A study of the effect of elastic piers upon arch design.

8.—A study of the effect of the deck and spandrel columns upon the stresses in arch bridges with open spandrels and the effect of spandrel walls upon the stresses in barrel arches. The Committee has received from Adolph Buehler, Chief Engineer of Bridges for the Swiss State Railways, a copy of his analysis of a large arch bridge in Switzerland with open spandrel, in which the entire structure was considered as acting as a unit.

D. H. Overman, Assistant Engineer, Ohio State Highway Department, is now carrying on a similar investigation of an arch bridge being designed for Ohio.

Finances

It is difficult to evaluate in money the time spent by members of the Committee and others who have donated their services to the work. If this were put on a fair basis, it would run into a large figure.

Cash contributions or their equivalent have been received as follows:

Engineering Foundation	$6 000
Blaw-Knox Company	150
American Society of Civil Engineers	2 700
Ohio State Highway Department (time of men and extra work)	1500
Division of Highways, Illinois (time of men, estimated)	300
American Bridge Company (concessions in material bought)	310
University of Illinois (time of staff)	2 700

The following budget for 1926 has been submitted to the Board of Direction of the Society for its approval:

Meeting expenses (three @ $500)	$1 500
Laboratory work at University of Illinois	1 500
Secretary's expenses	200
Chairman's expenses	100
Skew arch model tests at Princeton University	1 000
Field measurements of pier movements	600
Field measurements on bridges at Indianapolis, Ind.	1 000
Total	$5 900

Respectfully submitted,

CLYDE T. MORRIS, *Chairman,*
J. R. CHAMBERLIN,
E. H. HARDER,
A. C. JANNI,
W. M. WILSON,
GEORGE E. BEGGS, *Secretary.*

December 15, 1925.

At the request of Chairman Morris, the following memorandum on the death of John R. Chamberlin, M. Am. Soc. C. E., is appended herewith:

"It was with deep regret that we, the members of the Committee on Concrete and Reinforced Concrete Arches of the American Society of Civil Engineers, learned of the death of John R. Chamberlin.

"Mr. Chamberlin was appointed on the Committee in May, 1923, and was a faithful and interested participant in its work until his death. He brought a wealth of good judgment and wise council to our work, and his quiet, courteous manner and lovable disposition endeared him to all.

"We feel keenly the loss of his good council in our proceedings and of his genial presence, and wish to express our sorrow at his loss and our sympathy to his family, which has lost a kind and loving father.

"CLYDE T. MORRIS, *Chairman,*
GEORGE E. BEGGS, *Secretary,*
E. H. HARDER,
A. C. JANNI,
W. M. WILSON."

Progress Report of the Special Committee on Steel Column Research*

To the Board of Direction,

American Society of Civil Engineers:

1.—Preliminary Statement.—This Committee was authorized in August, 1923, and held its first meeting in October of that year. At this meeting, it was unanimously agreed that the first work of the Committee should be to make a thorough study of all existing data before undertaking any further tests. It was thought that it would doubtless be desirable to do further experimental work, but plans for any such work should be based on a careful study of all existing data. In order to carry out this program, it was obviously necessary to employ considerable assistance, and it was therefore arranged that M. O. Withey, Professor of Mechanics at the University of Wisconsin, should devote a large part of his time, during the year 1924-25, in assisting the Committee in this work. This plan was carried out, and the material thus brought together has been reviewed by the Committee at three meetings during the current year (1925). In addition to this review of existing data, a few preliminary tests have been made on six columns, with a view to developing the best method of testing the efficiency of lacing and other lateral connections. These tests have been made on the 1 000 000-lb. testing machine at the U. S. Forest Products Laboratory at Madison, Wis., and the University of Wisconsin has contributed to some extent in carrying on this program. These tests were made to assist the Committee in formulating any further program of experimentation. The Committee also desires to acknowledge the interest and financial assistance of Engineering Foundation in its work.

Although the Committee is not prepared to make a final report on its study of existing data, it has carried this work far enough to make it seem desirable to present some of the results in the form of a progress report.

2.—Division of the Subject.—In making a thorough study of the strength of structural steel columns, it appears to the Committee that the consideration of the subject may profitably be divided into four fairly distinct parts, as follows:

(A) Strength of relatively short columns $\left(\frac{l}{r} = 30 \text{ to } 100\right)$ of good design as compared to the elastic properties of the metal, as shown by compression and tension specimen tests.

(B) Results of all tests of columns heretofore made where failure was not due to weakness of detail. These results would give information particularly on effect of slenderness ratio and end conditions.

(C) Effect of various details, form of section, and method of manufacture. on the strength of columns.

* Presented to the Annual Meeting, January 20, 1926.

(D) A study of the column as a part of a structure, especially with reference to end conditions and relation to columns as tested; column theories; working formulas.

The first part (A) would include the very important questions of the significance of the elastic limit or yield point or the useful limit point of test specimens; relative value and reliability of mill tests; the tension test compared with the compression test; the variation of quality of steel over the cross-section; methods of determining the proper average quality; and, to some extent, the effect of form of section and grade of steel.

The second part (B) attempts to bring together all existing data in convenient form for discussion. Even if additional tests appear to be necessary, it is thought that the Committee's study on existing data should be presented without waiting for further tests.

The third part (C) would include a multitude of questions involved in the general problem of design, such as form of section, lacing, diaphragms, thickness of unsupported lengths and widths, tie-plates, pin-plates, riveting, etc. It should be the aim of this investigation to determine the requirements necessary to produce a column which would act substantially as a unit the strength of which could be estimated closely by a suitable column formula based on integral action.

The fourth part (D) would be more or less theoretical in character, but essential to the consideration of column formulas or factors of safety. The column in the testing machine acts under very different conditions from those which obtain in most structures.

Although a discussion of the various items under these four divisions will necessarily overlap somewhat, it is thought that better progress will be made by subdividing the material in this way.

This report covers Parts (A) and (B) and some items under Part (C).

(A) Relation of Strength of Relatively Short Columns $\left(\frac{l}{r} = 30 \text{ to } 100\right)$ to the Elastic Properties of the Metal

3.—Whatever formula may be used to express column strength, it is agreed that for axially loaded columns of slenderness ratio up to 50 or 60, at least, the effect of length is small, and that the strength of the column, if properly designed, is primarily a function of the elastic strength of the metal. A constant value of unit stress can well be used for columns of this length, provided the character of the metal is uniform; and such value, once determined, is of much significance in arriving at the column formula needed for the greater lengths. In a study of test data with respect to this phase of the question, a great many uncertainties are confronted, especially with reference to the quality of the material. In most cases the information is inadequate, and in some cases very unreliable or given in terms of doubtful meaning. After much study, it was decided that the most useful information could be obtained by a study of the ratio of the ultimate strength of columns of different length

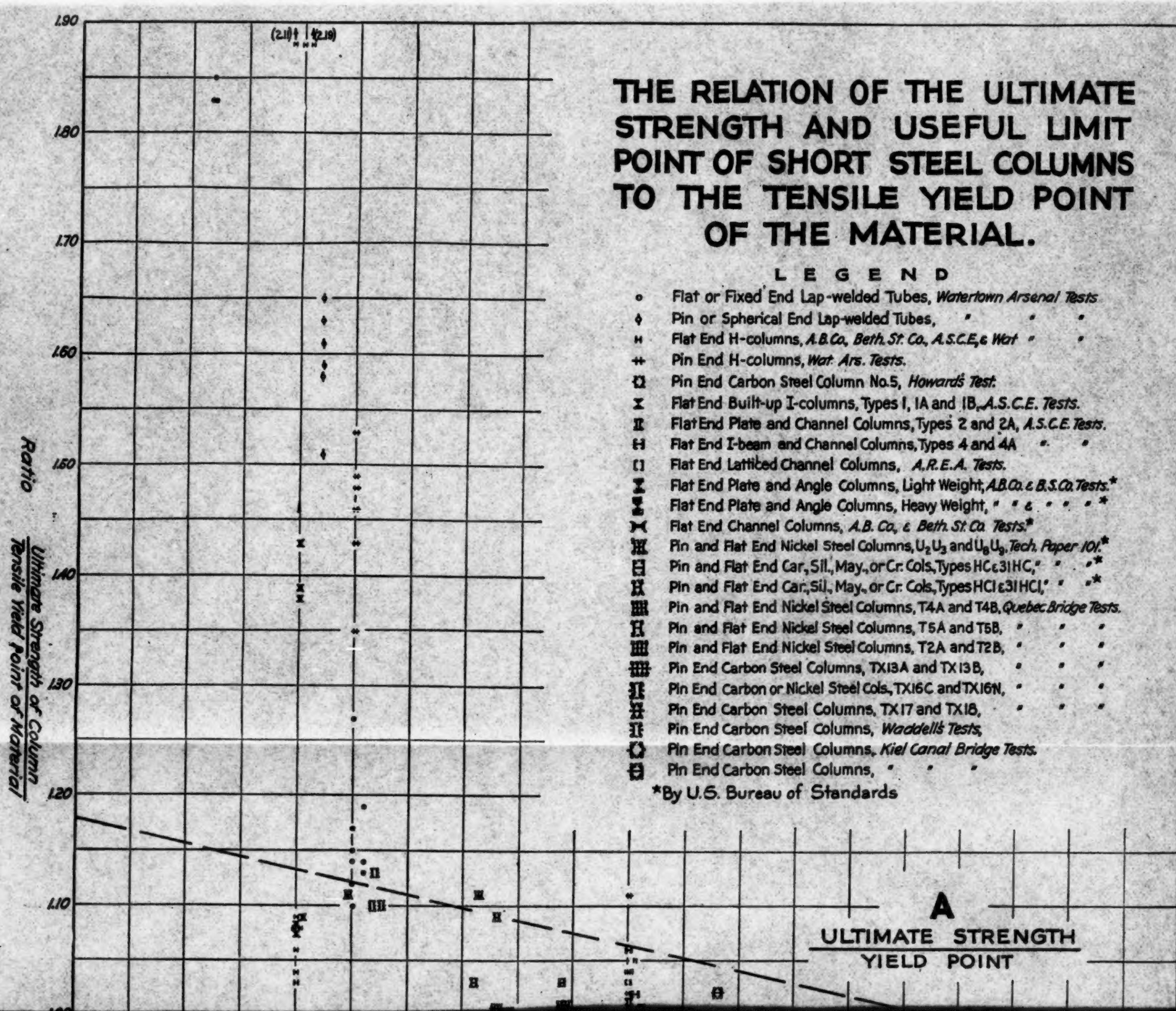
ratios up to $\frac{l}{r} = 100$ to the tensile yield point strength of the material. The Society's Special Committee on Steel Columns and Struts made use of what was named by it the "Useful Limit Point" (U. L. P.)* as being of more significance in some respects than the ultimate strength of the column or the yield point of the material. Although there is good ground for adopting this point in the stress-deformation diagram, as the best measure of column strength, it is not practicable to adhere to this method in a study of all available data. Information does not exist to determine the U. L. P. in a great many of the tests that have been made; but nevertheless it is believed that the results of such tests are valuable and cannot be neglected. As regards the material tests, the most reliable information appears to be the values of the tensile yield point, but in many cases this information is not very satisfactory.

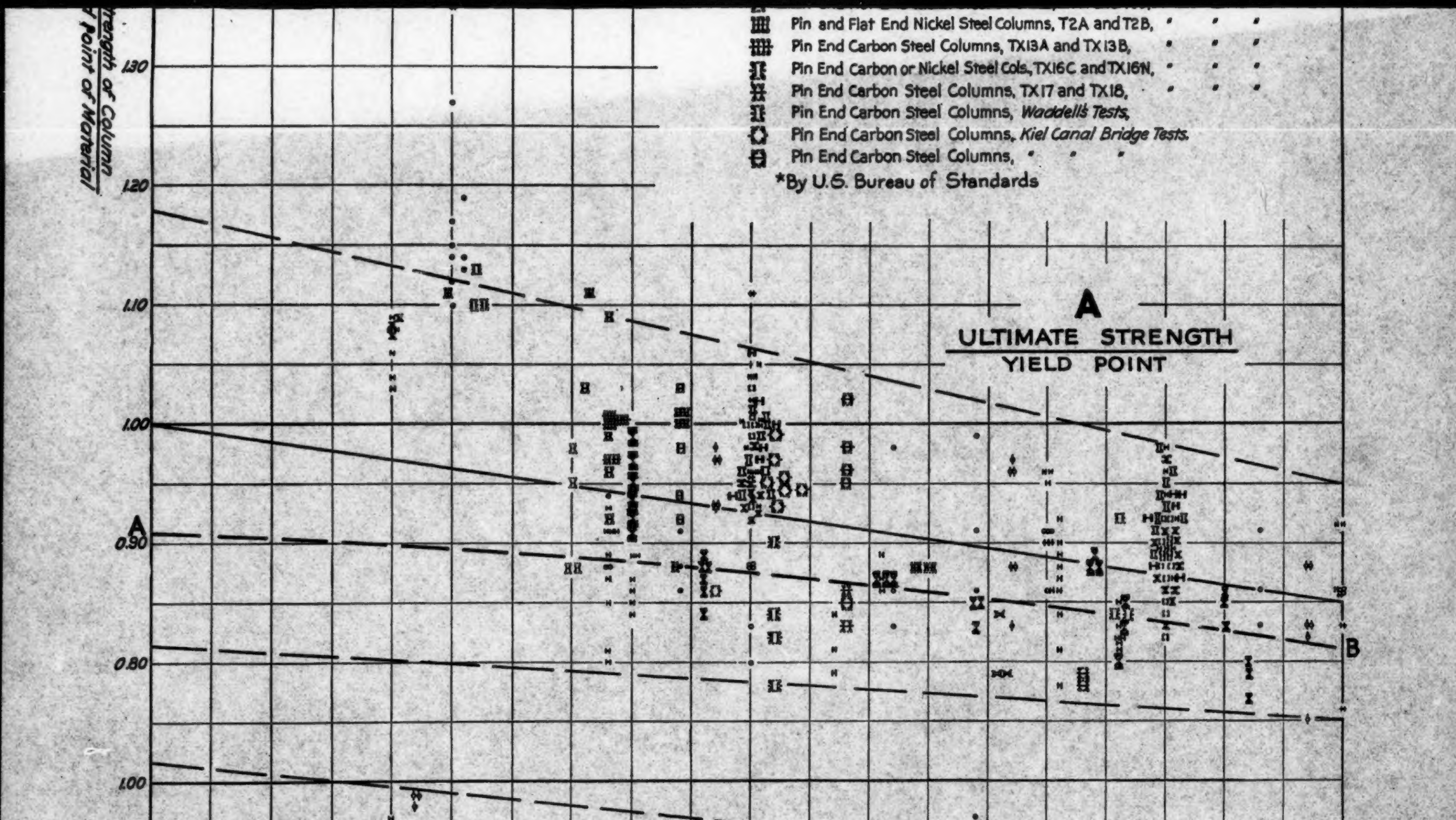
4.—Ratios of Ultimate Strength and Useful Limit Point of Columns to Tensile Yield Point of Material.—The Committee has examined all available tests of steel columns, and has shown in Plate I and Table 1 the results of all tests for $\frac{l}{r}$ up to 100 where failure appeared to be due primarily to a general over-stressing of the material, and where the information regarding the yield point strength of the material was fairly reliable. The results are plotted in Plate I (*A*) as ratios of ultimate strength to yield point strength. Each point represents an individual result. The legend shows what test data have been used; and it will be noticed that pin-ended columns are included, also alloy steel, as well as carbon steels. In using a simple ratio of strength of column to strength of metal, it is recognized that the slenderness ratio has some effect below $\frac{l}{r} = 100$, and, therefore, the results for the hard alloy steels are not quite comparable to the structural steel columns for the higher values of $\frac{l}{r}$; but the difference is relatively small, and it was thought desirable to use all values up to 100 in this study. Columns which failed because of some weak detail, or because of purposely eccentric loading, are omitted. The general make-up of the columns is shown by the symbols on the diagram.

The results are scattered over a rather wide range of values, the limits, except for $\frac{l}{r}$ less than 30, being indicated closely by the two straight lines shown in Plate I. The central straight line represents fairly well average values. Some of the variation in strength is due undoubtedly to the uncertainty regarding yield point of the material, and probably the high values for the tests of the Special Committee on Steel Columns and Struts† at $\frac{l}{r} = 50$ are due in part to the use of a lower value for yield point than for some of the other tests. There appears to be little effect of form of column, although most of the larger built-up columns are below the center line.

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 1618.

† *Loc. cit.*, p. 1583.


THE RELATION OF THE ULTIMATE STRENGTH AND USEFUL LIMIT POINT OF SHORT STEEL COLUMNS TO THE TENSILE YIELD POINT OF THE MATERIAL.
LEGEND
Flat or Fixed End Lap-welded Tubes, Watertown Arsenal Tests
Pin or Spherical End Lap-welded Tubes, " " "
Flat End H-columns, A.B.Co., Beth. St. Co., A.S.C.E., & Wat " "
Pin End H-columns, Wat. Ars. Tests.
Pin End Carbon Steel Column No.5, Howard's Test.
Flat End Built-up I-columns, Types I, IA and IB, A.S.C.E. Tests.
Flat End Plate and Channel Columns, Types 2 and 2A, A.S.C.E. Tests.
Flat End I-beam and Channel Columns, Types 4 and 4A " "
Flat End Latticed Channel Columns, A.R.E.A. Tests.
Flat End Plate and Angle Columns, Light Weight, A.B.Co. & B.S.Co. Tests.*
Flat End Plate and Angle Columns, Heavy Weight, " " & " " " *
Flat End Channel Columns, A.B. Co., & Beth. St. Co. Tests.*
Pin and Flat End Nickel Steel Columns, U2U3 and U8U9, Tech. Paper 101.*
Pin and Flat End Car., Sil., May., or Cr. Cols., Types HC & 31HC, " " "*
Pin and Flat End Car., Sil., May., or Cr. Cols., Types HC1 & 31HC1, " " "*
Pin and Flat End Nickel Steel Columns, T4A and T4B, Quebec Bridge Tests.
Pin and Flat End Nickel Steel Columns, T5A and T5B, " " "
Pin and Flat End Nickel Steel Columns, T2A and T2B, " " "
Pin End Carbon Steel Columns, TX13A and TX13B, " " "
Pin End Carbon or Nickel Steel Cols., TX16C and TX16N, " " "
Pin End Carbon Steel Columns, TX17 and TX18, " " "
Pin End Carbon Steel Columns, Waddell's Tests,
Pin End Carbon Steel Columns, Kiel Canal Bridge Tests.
Pin End Carbon Steel Columns, " " "
*By U.S. Bureau of Standards
A
ULTIMATE STRENGTH / YIELD POINT
Ratio Ultimate Strength of Column / Tensile Yield Point of Material
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
(2.11)
(2.19)



...rength of Column
...Point of Material
1.30
1.20
1.10
1.00
0.90
0.80
1.00
A
B
Pin and Flat End Nickel Steel Columns, T2A and T2B, * * *
Pin End Carbon Steel Columns, TX13A and TX13B, * * *
Pin End Carbon or Nickel Steel Cols., TX16C and TX16N, * * *
Pin End Carbon Steel Columns, TX17 and TX18, * * *
Pin End Carbon Steel Columns, Waddell's Tests,
Pin End Carbon Steel Columns, Kiel Canal Bridge Tests.
Pin End Carbon Steel Columns, * * *
*By U.S. Bureau of Standards
A
ULTIMATE STRENGTH
YIELD POINT

PLATE I.
PROCEEDINGS, AM. SOC. C. E.
MARCH, 1926.
PROGRESS REPORT OF SPECIAL COMMITTEE
ON STEEL COLUMN RESEARCH.

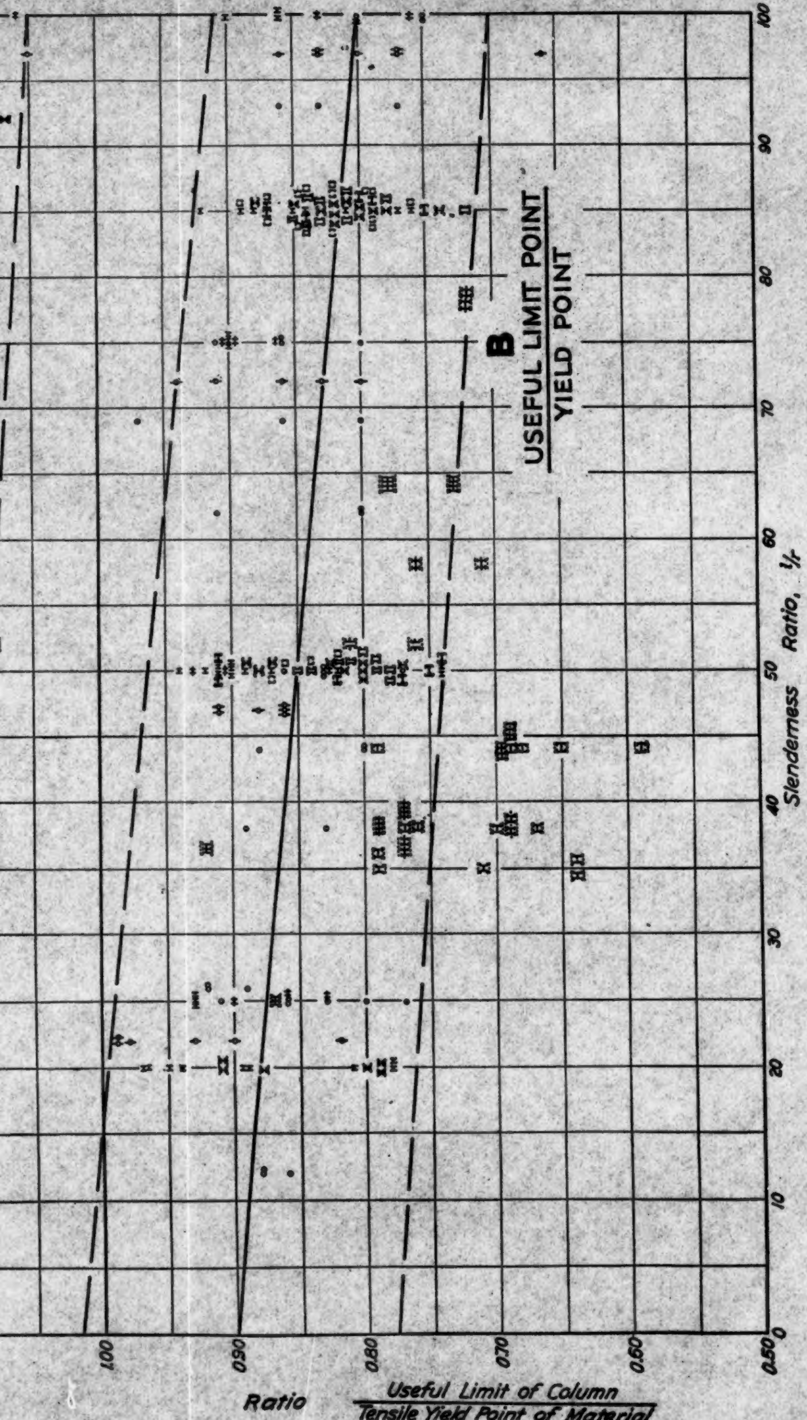


TABLE 1. THE RELATION OF THE STRENGTH OF SHORT COLUMNS TO THE YIELD POINT OF THE METAL

TABLE 1.—THE RELATION OF THE STRENGTH OF SHORT COLUMNS TO THE YIELD POINT OF THE METAL.

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
DATA FROM TESTS OF METALS AND OTHER MATERIALS, WATERTOWN ARSENAL.											
1908	Flat	Steel tubing	1895	5.2	12	36.2 (Avg. of three tests)	67.0	32.0	1.85	0.88	Bulged at ends.
			1896				66.4	32.0	1.83	0.88	“ “ “
			1897				66.2	31.0	1.83	0.86	“ “ “
								Ave.	1.84	0.87	
1909	Flat		1891	5.2	25	Called elastic limit in report.	41.7	33.0	1.15	0.91	Triple flexure after ultimate.
			1892				40.6	30.0	1.12	0.83	“ “ “ “
			1893				39.8	29.0	1.10	0.80	“ “ “ “
			1898				46.0	31.0	1.27	0.86	“ “ “ “
			1899				42.3	31.0	1.17	0.86	“ “ “ “
			1900				41.4	28.0	1.14	0.77	“ “ “ “
								Ave.	1.16	0.84	
1909	Flat		1901	5.2	38	36.2	34.0	32.0	0.94	0.88	Triple flexure after ultimate.
			1902				32.0	30.0	0.88	0.83	“ “ “ “
			1903				31.7	27.0	0.88	0.75	“ “ “ “
								Ave.	0.90	0.82	
1909	Flat		1888	5.2	50	36.2	28.8	....	0.80	....	Triple flexure after ultimate.
			1889				32.0	30.0	0.88	0.83	“ “ “ “
			1890				32.0	30.0	0.88	0.83	“ “ “ “
			1904				30.0	28.0	0.83	0.77	“ “ “ “
			1905				32.0	31.0	0.88	0.86	“ “ “ “
			1906				32.0	30.0	0.88	0.83	“ “ “ “
								Ave.	0.86	0.82	

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from Tests of Metals and Other Materials, Watertown Arsenal.											
1909	Flat.....		1907	5.2	62	36.2	35.6	33.0	0.98	0.91	Triple flexure after ultimate.
			1908				31.0	29.0	0.86	0.80	" " " "
			1909				30.0	29.0	0.83	0.80	" " " "
								Ave........	0.89	0.84	
1909	Flat.....		1894	5.2	75	36.2	33.0	31.0	0.91	0.86	Triple flexure after ultimate.
			1885				33.0	33.0	0.91	0.91	" " " "
			1886				33.0	31.0	0.91	0.86	" " " "
			1887				31.0	29.0	0.86	0.80	" " " "
								Ave........	0.90	0.86	
1909	Flat.....		1882	5.2	100	36.2	31.0	27.0	0.86	0.75	Triple flexure after ultimate.
			1883				31.0	27.0	0.86	0.75	" " " "
			1884				31.0	29.0	0.86	0.80	" " " "
								Ave........	0.86	0.77	
1909	Fixed....		1977	5.2	26	36.2	41.4	33.4 S	1.14	0.92	Scaling triple flexure after ultimate.
			1978				41.0	32.4 S	1.13	0.92	" " " " "
			1979				43.0	32.3 S	1.19	0.89	" " " " "
								Ave........	1.15	0.91	

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios. Ultimate / Yield point $= \frac{S'}{S_y}$	U. L. P. / Yield point $= \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from Tests of Metals and Other Materials, Watertown Arsenal.											
1909	Fixed....		1974	5.2	44	36.2	32.0	29.0	0.88	0.80	Triple flexure after ultimate.
			1975				33.0	32.0	0.91	0.83	" " " "
			1976				31.0	29.0	0.86	0.80	" " " "
								Ave........	0.88	0.83	
1909	Fixed....		1971	5.2	69	36.2	33.0	31.0	0.91	0.86	Triple flexure after ultimate.
			1972				36.0	35.0	0.99	0.97	" " " "
			1973				31.0	29.0	0.86	0.80	" " " "
								Ave........	0.92	0.88	
1909	Fixed....		1968	5.2	93	36.2	31.0	30.0	0.86	0.83	Triple flexure after ultimate.
			1969				30.0	28.0	0.83	0.77	" " " "
			1970				32.8	31.0	0.91	0.86	" " " "
								Ave........	0.87	0.82	
1909	Spherical		1929	5.2	22	36.2	57.2	33.6 S	1.58	0.93	Bulging at ends and triple flexure.
			1930				57.5	35.9 S	1.59	0.99	" " " " " "
			1931				58.9	35.7 S	1.63	0.99	" " " " " "
								Ave........	1.60	0.97	

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios. Ultimate / Yield point $= \frac{S'}{S_y}$	U. L. P. / Yield point $= \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
DATA FROM TESTS OF METALS AND OTHER MATERIALS, WATERTOWN ARSENAL.											
1909	Spherical		1926	5.2	47	36.2	35.0	32.0	0.97	0.88	Deflection small at ultimate, rapidly increasing after maximum load.
			1927				33.6	31.0	0.93	0.86	
			1928				33.8	31.0	0.93	0.86	
								Ave.......	0.94	0.87	
1909	Spherical		1923	5.2	72	36.2	34.6	33.0	0.96	0.91	....
			1924				35.0	31.0	0.97	0.86	....
			1925				34.7	34.0	0.96	0.94	....
								Ave.......	0.96	0.90	
1909	Pin		1920	5.2	97	36.2	32.0	30.0	0.88	0.83	....
			1921				30.2	28.0	0.83	0.77	....
			1922				29.7	29.0	0.82	0.80	....
								Ave.......	0.84	0.80	
1909	Pin		1950	5.2	22	36.2	58.2	32.7 S	1.61	0.90	Bulging at ends and deflection.
			1951				54.5	29.6 S	1.51	0.82	Deflected normal to pins.
			1952				59.6	35.3 S	1.65	0.98	Bulging at ends and triple flexure.
								Ave..	1.59	0.90	

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: Ultimate / Yield point $= \frac{S'}{S_y}$.	U. L. P. / Yield point $= \frac{S''}{S_y}$.	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from Tests of Metals and Other Materials, Watertown Arsenal.											
1909	Pin		1947	5.2	47	36.2	33.5	31.0	0.93	0.86	Little deflection until after the maximum load had been reached, then columns deflected normal to pins except No. 1945, which deflected in plane of pins.
			1948				35.0	33.0	0.97	0.91	
			1949				35.6	33.0	0.98	0.91	
								Ave........	0.96	0.89	
1909	Pin		1944	5.2	72	36.2	30.0	29.05	0.83	0.80	
			1945				32.0	...	0.88	....	
			1946				31.8	30.0	0.88	0.83	
								Ave........	0.86	0.81	
1909	Pin		1941	5.2	97	36.2	27.0	24.0	0.75	0.66	....
			1942				30.0	28.0 (?)	0.83	0.77	....
			1943				32.0	30.0 (?)	0.88	0.83	....
								Ave........	0.82	0.75	

TABLE 1.—(*Continued.*)

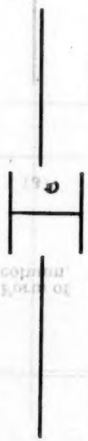
Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: Ultimate / Yield point $= \frac{S'}{S_y}$.	U. L. P. / Yield point $\frac{S''}{S_y}$.	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from Tests of Metals and Other Materials, Watertown Arsenal.											
1908-09	Flat		1855	7	25	30.1 (Average of four flange specimens called elastic limit in report.)	43.1	28.0	1.43	0.93	Flanges buckled.
			1856				40.7	28.0	1.35	0.93	" "
			1857				44.7	28.0	1.48	0.93	" "
								Ave.......	1.42	0.93	
1908-09	Flat		1858	7	50		29.0	27.0	0.96	0.90	Triple flexure after ultimate.
			1859				28.6	27.0	0.95	0.90	" " " "
			1860				29.0	27.0	0.96	0.90	" " " "
								Ave.......	0.96	0.90	
1908-09	Flat		1861	7	75		29.0	27.0	0.96	0.90	Triple flexure after ultimate.
			1862				29.0	27.0	0.96	0.90	" " " "
			1863				28.6	27.0	0.95	0.90	" " " "
								Ave.......	0.96	0.90	
1908-09	Flat		1864	7	100	30.1	28.0	27.0	0.93	0.90	Triple flexure after ultimate.
			1865				26.0	24.0	0.86	0.80	" " " "
			1866				28.0	26.0	0.93	0.86	" " " "
								Ave.......	0.91	0.85	

TABLE 1.—(*Continued.*)

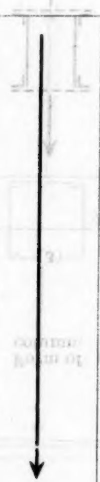
Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$.	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$.	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$.	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from Tests of Metals and Other Materials, Watertown Arsenal.											
1908-09	Pin		1995	7	25	30.1	45.0	27.0	1.49	0.90	Flanges buckled.
			1996				44.0	25.0	1.46	0.83	" "
			1997				46.0	26.0	1.53	0.86	....
								Ave.........	1.49	0.86	
1908-09	Pin		1992	7	50	30.1	28.8	25.0	0.96	0.83	Little deflection until maximum load was applied then column rapidly deflected in plane normal to webs (and pin axes).
			1993				33.4	27.0	1.11	0.90	
			1994				30.8	28.0	1.02	0.93	
								Ave........	1.03	0.89	
1908-09	Pin		1989	7	75	30.1	28.0	27.0	0.93	0.90	....
			1990				28.0	27.0	0.93	0.90	....
			1991				28.6	26.0	0.95	0.86	....
								Ave........	0.94	0.89	
1908-09	Pin		1986	7	100	30.1	24.0	23.0	0.80	0.76	....
			1987				26.0	25.0	0.86	0.83	....
			1988				27.0	26.0	0.90	0.86	....
								Ave........	0.85	0.82	

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. in. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from Waddell Tests.*											
1909	Pin......		1	17.4	27	35.4	38.9	34.0	1.10	0.96	Carbon steel. Short columns failed by buckling of flanges and webs; long columns by bending in plane normal to pins.
			2				39.8	32.0	1.13	0.90	
			3				38.9	29.0	1.10	0.82	
								Ave.......	1.11	0.89	....
1909	Pin......		1	17.4	81	35.4	29.6	....	0.84	....	....
			2				32.4	29.0	0.92	0.82	....
			3				29.6	28.0	0.84	0.79	....
								Ave........	0.87	0.80	
Data from Howard Tests.†											
1911	Pin........		5	90.0	47	35.4	30.5	....	0.86	....	....

* *Transactions*, Am. Soc. C. E., Vol. LXIII (1909), p. 101.
† *Loc. cit.*, Vol. LXXIII (1911), p. 429.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from American Railway Engineering Association Tests.											
1915	Flat		12	9.6	50	Specifi-	37.9	....	1.00	....	
			57	....	..	cations	39.3	32.6	1.08	0.86	Deflected south and up.
			74	....	..	38.0	38.2	33.0	1.00	0.87	" " " down.
			7	12.5	50	±1.0	38.5	....	1.01	....	Triple flexure.
			72	....	..	....	37.7	32.0	0.99	0.84	Buckling down and north.
			73	....	..	....	35.4	31.0	0.93	0.82	" " " "
								Ave.	0.99	0.85	
1915	Flat		17	9.6	85	....	32.9	30.0	0.87	0.79	Triple flexure.
			58	....	..	....	35.0	34.0	0.92	0.89	Triple flexure, buckling at center.
			61	....	..	....	34.1	33.0	0.90	0.87	Deflected north and up.
			20	12.5	85	....	34.1	32.0	0.90	0.84	Triple flexure, buckling at center.
			60	....	..	....	34.9	32.0	0.92	0.84	....
			62	....	..	....	34.0	30.0	0.89	0.79	....
			191	9.6	85	....	33.9	30.0	0.89	0.79	....
			192	....	..	....	33.9	33.0	0.89	0.87	....
			197	....	..	....	33.9	31.0	0.89	0.82	....
			199	9.6	85	....	33.6	32.0	0.88	0.84	....
			200	....	..	....	33.5	32.0	0.88	0.84	....
			204	....	..	....	31.2	31.0	0.90	6.82	....
			201	12.5	85	....	32.1	31.0	0.84	0.82	....
			202	....	..	....	31.0	29.0	0.82	0.76	....
			203	....	..	....	32.4	30.0	0.85	0.79	....
								Ave.	0.88	0.82	

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
						Data from American Bridge Company and Bethlehem Steel Company Tests.					
....	Flat......		ABC	36	40	40.6	35.0	....	0.86	....	
						39.8	35.6	....	0.89	....	
						41.1	35.8	....	0.87	....	
			B	36	40	36.2	32.1	....	0.89	....	
						37.0	31.5	....	0.85	....	
						38.4	32.2	....	0.84	....	
								Ave......	0.87	....	
....	Flat......		ABC	35.5	61	40.1	35.8	....	0.89	....	
						40.9	35.0	....	0.86	....	
						40.5	35.8	....	0.87	....	
								Ave......	0.87	....	
....	Flat......		ABC	35.5	81	44.8	37.9	....	0.85	....	
						42.9	35.3	....	0.82	....	
						45.1	36.8	....	0.82	....	
			B	35.5	81	38.4	32.0	....	0.83	....	
						38.0	31.1	....	0.82	....	
						37.2	30.1	....	0.81	....	
								Ave......	0.82	....	
....	Flat......		ABC	33	38	34.9	28.2	....	0.81	....	
						30.5	25.8	....	0.85	....	
						32.3	25.9	....	0.80	....	
			B	33	38	38.1	34.0	....	0.89	....	
						39.4	36.0	....	0.91	....	
						40.1	35.0	....	0.87	....	
								Ave......	0.86	...	

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of columns.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: Ultimate / Yield point $= \frac{S'}{S_y}$	U. L. P. / Yield point $= \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data From American Bridge Company and Bethlehem Steel Company Tests											
....	Flat......		ABC	83	57	33.6	26.7	....	0.79	....	....
						30.0	25.8	....	0.84	....	....
						33.1	26.7	....	0.81	....	....
								Ave........	0.81	....	
....	Flat......		ABC	83	76	35.1	28.4	....	0.81	....	....
						31.4	24.5	....	0.78	....	....
						33.4	28.7	....	0.86	....	....
						38.8	34.4	....	0.89	....	....
			B	83	76	39.1	36.0	....	0.92	....	....
						40.0	33.6	....	0.84	....	....
								Ave........	0.85	....	
....	Flat......		B	85.4	38	43.3	39.4	....	0.91	....	....
						44.8	41.0	....	0.91	....	....
						43.9	41.0	....	0.93	....	....
								Ave........	0.92	....	
....	Flat......		B	85.4	76	44.2	39.7	....	0.90	....	....
						44.1	38.6	....	0.88	....	....
						43.8	38.1	....	0.87	....	....
								Ave........	0.88	....	

TABLE 1.—(*Continued.*)

Series. (1)	End conditions. (2)	Form of column. (3)	Column no. (4)	Area of section, in square inches. (5)	$\frac{l}{r}$ (6)	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y. (7)	Column at ultimate, S'. (8)	Column at U. L. P., S''. (9)	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$ (10)	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$ (11)	Remarks. (12)
Data from American Bridge Company and Bethlehem Steel Company Tests.											
....	Flat		ABC	37.0	46	41.0	36.6	....	0.89	....	....
						41.0	35.8	....	0.87	....	....
						41.2	36.3	....	0.88	....	....
			B	35.8	46	38.1	33.7	....	0.88	....	....
						38.0	32.0	....	0.84	....	....
						38.2	32.9	....	0.86	....	....
								Ave........	0.87		
....	Flat		ABC	37.3	69	39.3	32.7	....	0.83	....	....
						39.3	33.3	....	0.85	....	....
						38.1	32.4	....	0.85	....	....
								Ave........	0.84		
....	Flat		ABC	37.2	92	39.3	31.6	....	0.80	....	....
						40.0	30.9	....	0.77	....	....
						39.3	31.2	....	0.79	....	....
			B	35.8	90	37.2	31.9	....	0.86	....	....
						36.3	30.9	....	0.85	....	....
						36.0	30.0	....	0.83	....	....
								Ave........	0.83		
....	Flat		ABC	35.0	40	38.6	37.6	....	0.97	....	....
						38.2	36.3	....	0.95	....	....
						37.4	37.1	....	0.99	....	....
			B	33.1	40	33.9	31.8	....	0.94	....	....
						35.1	31.8	....	0.91	....	....
						33.6	31.8	....	0.92	....	....
								Ave........	0.95		

TABLE 1.—(*Continued.*)

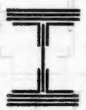
Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	STRENGTH, IN 1 000 LB. PER SQ. IN. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	RATIOS: Ultimate / Yield point $= \frac{S'}{S_y}$	U. L. P. / Yield point $= \frac{S''}{S_y}$	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
DATA FROM AMERICAN BRIDGE COMPANY AND BETHLEHEM STEEL COMPANY TESTS.											
....	Flat		ABC	85	61	35.7	31.2	....	0.87	....	....
						35.3	30.7	....	0.87	....	....
						35.8	31.3	....	0.87	....	....
								Ave........	0.87		
....	Flat		ABC	85	81	39.8	32.9	....	0.83	....	....
						35.9	30.5	....	0.85	....	....
						37.6	30.2	....	0.80	....	....
			B	83	79	34.1	30.3	....	0.89	....	....
						34.0	30.0	....	0.88	....	....
						34.0	30.0	....	0.88	....	....
								Ave........	0.86		
....	Flat		ABC	39.9	71	42.8	34.0	....	0.79	....	....
						42.8	33.9	....	0.79	....	....
						42.8	35.8	....	0.84	....	....
								Ave........	0.81		

TABLE 1.—(*Continued.*)

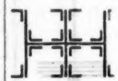
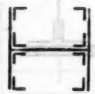
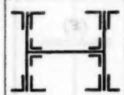
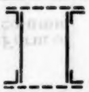
Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	STRENGTH, IN 1 000 LB. PER SQ. IN. OF: Metal at yield point, S_y	Column at ultimate, S'.	Column at U. L. P., S''.	RATIOS: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
DATA FROM TESTS IN *Technologic Paper No. 101*, U. S. BUREAU OF STANDARDS.											
....	Pin and flat....		$U_2\ U_8$	88.8	25	55.5	61.7	48.0	1.11	0.87	Nickel-steel angles buckled near end.
			$U_8\ U_9$	88.8	37	55.2	61.4	51.0	1.11	0.92	Angles buckled near end.
								Ave........	1.11	0.90	
....	Pin and flat....		HC	74.6	44	40.7	38.4	28.0	0.94	0.69	Carbon steel. Buckled at center.
			31HC	76.9	44	42.9	41.7	29.0	0.98	0.68	Carbon steel. Deflection normal to pin.
								Ave........	0.96	0.68	
....	Pin and flat....		HC1	75.3	36	44.1	45.3	35 +	1.03	0.79	Carbon steel. Deflection parallel to pin.
			31HC1	77.2	38	42.7	46.6	32.5	1.09	0.76	Carbon steel, center web buckled. Column deflection normal to pin.
								Ave........	1.06	0.78	
....	Pin and flat....	See HC	32S	76.9	44	57.2	52.8	37.0	0.92	0.65	Silicon steel. Center web buckled and column deflected normal to pin.
		See HCI	32S1	77.2	38	56.5	51.7	39.5	0.92	0.70	Silicon steel. Center web buckled and column deflected normal to pin.
....	Pin and flat....	See HC	MY	74.9	44	59.9	61.5	47.0	1.03	0.79	Mayari steel. Deflection normal to pin.
		See HCI	MY1	75.3	38	62.1	64.7	48.0	1.04	0.77	Mayari steel. Deflection normal to pin.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: Ultimate / Yield point $= \frac{S'}{S_y}$	U. L. P. / Yield point $= \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from Tests in *Technologic Paper No. 101*, U. S. Bureau of Standards.											
....	Pin and flat	See HC See HCI	34CS 34CS1	76.9 77.2	44 38	55.3 54.2	49.2 51.8	33.0 36.5	0.88 0.96	0.59 0.67	Carbon steel. Center web and lacing buckled. Column deflection normal to pin.
Data from Quebec Bridge Tests.											
....	Pin and flat		T4A T4B	45.8	64	58.0	50.8 51.3	45.5* 42.8*	0.88 0.88	0.78 0.73	Nickel steel. Deflection failure. Deflection failure.
								Ave........	0.88	0.76	
....	Pin and flat		T5BL T5AL	52.3	35	58.0	51.0 51.1	37.0* 37.0*	0.88 0.88	0.64 0.64	Nickel steel. Buckling near transverse diaphragm.
								Ave........	0.88	0.64	
....	Pin and flat		T2A T2B	40.2	44	58.0	57.8 58.3	40.1* 40.1*	1.00 1.01	0.69 0.69	
								Ave........	1.00	0.69	
....	Pin and flat		T5AS T5BS	27.6	35	58.0	55.0 57.0	42.0* 45.6*	0.95 0.98	0.72 0.79	
								Ave........	0.96	0.76	

* Signifies that the recorded values were designated elastic limits in the report of the Quebec Bridge tests. Since the U. L. P. could not be determined from the stress-strain curves of these columns, these elastic limits were inserted herein. They are somewhat lower than the U. L. P. values.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from Quebec Bridge Tests.											
....	Pin......		TX13A1 TX13A2	68.9	38	40.5	39.3 40.7	28.0 31.0	0.97 1.00*	0.69 0.77	Carbon steel. Flanges buckled at center. Deflection perpendicular to pins. No failure until two 1-in. holes were bored in middle of each web-plate.
								Ave........	0.99*	0.73	
....	Pin......		TX13B1 TX13B2	69.0	38	40.5	40.5* 40.5*	31.0 32.0	1.00* 1.00*	0.77 0.79	
								Ave........	1.00*	0.78	
....	Pin......		TX16C1 TX16C2	34.8	52	40.9	36.6 33.4	31.0 33.0	0.90 0.82	0.76 0.81	Ribs buckled near center splice.
								Ave........	0.86	0.78	
....	Pin......	See TX 16 c	TX16N1 TX16N2	34.6	52	61.2	47.5 51.6	....	0.78 0.84	....	Nickel steel. Ribs buckled.
								Ave........	0.82	....	
....	Pin......		TX17-1 TX17-2	41.1	78	41.7	32.6 33.0	30.0 30.0	0.78 0.79	0.72 0.72	Carbon steel. Lower flange buckled. Deflection perpendicular to pins. One rib buckled. Deflection perpendicular to pins.
								Ave........	0.78	0.72	

* Signifies that the recorded values were designated elastic limits in the report of the Quebec Bridge tests. Since the U. L. P. could not be determined from the stress-strain curves of these columns, these elastic limits were inserted herein. They are somewhat lower than the U. L. P. values.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point. S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: Ultimate / Yield point $= \frac{S'}{S_y}$	Ultimate / Yield point $= \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
						Data from Quebec Bridge Tests.					
....	Pin		TX18-1 TX18-2	56.1	58	40.9	33.8 35.1	29.0 31.0	0.83 0.86	0.71 0.76	Deflection perpendicular to pins.
								Ave........	0.84	0.74	
						Data from Special Committee on Steel Columns and Struts Tests.*					
919	Flat		178 179 180	11.4	20	35.1	38.2 38.4 38.0	32.0 32.0 31.0	1.08 1.09 1.08	0.91 0.91 0.88	Flanges buckled.†
								Ave........	1.08	0.90	
1919	Flat		175 176 177	22.1	20	31.2	43.3 43.4 44.5	24.5 25.0 25.0	1.38 1.39 1.43	0.79 0.80 0.80	Flanges buckled.†
								Ave........	1.40	0.80	
1919	Flat		8 38 77	11.1	50	35.1	32.4 32.8 33.0	28.3 29.2 29.0	0.92 0.93 0.94	0.80 0.83 0.82	Flanges buckled. " " Failed by deflection.
								Ave........	0.93	0.82	

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 1634.

† Indicated from photograph.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
						Data from Special Committee on Steel Columns and Struts Tests.*					
1919	Flat		93 96 97	22.2	50	31.2	29.0 28.9 29.7	25.0 24.0 25.0	0.93 0.93 0.95	0.80 0.77 0.80	Deflection failure.†
								Ave........	0.94	0.79	
1919	Flat		18 84 85	11.4	85	35.1	32.1 31.4 30.0	26.0 30.0 27.5	0.91 0.89 0.85	0.74 0.85 0.78	Flanges buckled.
								Ave........	0.88	0.79	
1919	Flat		91 94 95	22.0	85	31.2	28.0 28.2 28.0	25.7 24.7 25.5	0.90 0.91 0.90	0.82 0.79 0.82	Deflection failure.†
								Ave........	0.90	0.81	
1919	Flat		229 230 231	28.4	85	32.5	28.2 27.0 28.0	26.5 26.0 26.0	0.87 0.83 0.86	0.82 0.80 0.80	Deflection failure.
								Ave........	0.85	0.81	

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 1634.

† Indicated from photograph.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In., in of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
						Data from Special Committee on Steel Columns and Struts Tests.*					
1919	Flat		30	11.2	120	35.1	28.6	25.4	0.81	0.72	....
			56				27.6	26.3	0.79	0.75	....
			69				28.7	28.0	0.82	0.80	....
								Ave........	0.81	0.76	
1919	Flat		92	22.1	120	31.2	25.0	23.0	0.80	0.74	....
			98				25.5	23.5	0.82	0.75	....
			99				25.8	23.3	0.83	0.75	....
								Ave........	0.82	0.75	
1919	Flat		207	11.7	155	35.1	27.0	26.0	0.77	0.74	....
			218				25.6	25.0	0.76	0.71	....
			222				26.0	24.5	0.74	0.70	....
								Ave........	0.76	0.72	
1919	Flat		205	22.3	155	31.2	22.2	21.3	0.71	0.68	....
			206				23.2	22.4	0.74	0.72	....
			208				22.7	21.0	0.73	0.67	....
								Ave........	0.73	0.69	

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 1634.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from Special Committee on Steel Columns and Struts Tests.*											
1919	Flat......		5	13.3	50	35.0	34.3	30.3	0.98	0.87	
			37				32.7	30.6	0.94	0.88	Failed by buckling of angle legs.
			76				33.2	31.0	0.95	0.89	Failed by deflection.
								Ave........	0.96	0.88	
1919	Flat......		15	13.4	85	35.0	34.0	30.8	0.97	0.88	Triple flexure,
			89				30.0	29.0	0.86	0.83	Failed by deflection upward.
			90				30.7	28.5	0.88	0.81	Failed by deflection.
								Ave........	0.90	0.84	
1919	Flat......		28	13.3	120	35.0	28.3	28.3	0.81	0.81	....
			48				26.9	25.9	0.77	0.74	....
			51				29.0	25.6	0.83	0.73	....
								Ave........	0.80	0.76	
1919	Flat......		107X	9.2	20	38.1	39.6	34.0	1.04	0.89	Flanges buckled.†
			108X				41.0	36.0	1.08	0.94	" "
			114X				41.0	37.0	1.08	0.97	" " .†
								Ave........	1.07	0.93	

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 1634.

† Indicated from photograph.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point S_y.	Column at ultimate, S'	Column at U. L. P., S''.	Ratios: Ultimate / Yield point $= \frac{S'}{S_y}$	U. L. P. / Yield point $= \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
				DATA FROM SPECIAL COMMITTEE ON STEEL COLUMNS AND STRUTS TESTS.*							
1919	Flat......		106X	18.3	20	34.7	35.6	31.0	1.03	0.89	55 200 maximum load obtained in emphasizing failure. Flanges buckled.
			112X				37.8	33.0	1.09	0.95	
			117X				36.7	33.5	1.06	0.97	
								Ave.......	1.06	0.94	
1919	Flat......		181CX	26.6	20	25.8	48.1	21.0	1.88	0.81	Flanges buckled.†
			183BX				54.5	20.0	2.11	0.78	....
			225AX				56.6	20.2	2.19	0.78	....
								Ave.......	2.06	0.79	
1919	Flat......		107	9.6	50	38.1	38.0	35.0	1.00	0.92	Buckling of flanges.
			122				38.0	34.5	1.00	0.91	....
			123				38.0	34.5	1.00	0.91	Buckling of flanges.
								Ave.......	1.00	0.91	
1919	Flat......		106	17.8	50	34.7	34.0	30.0	.98	0.87	....
			120				36.1	31.0	1.04	0.89	....
			121				36.0	32.5	1.04	0.94	....
								Ave.......	1.02	0.90	

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p, 1634.

† Indicated from photograph.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from Special Committee on Steel Columns and Struts Tests.*											
1919	Flat......		225	27.4	50	25.8	24.0	19.0	0.93	0.74	....
			226				24.6	21.1	0.96	0.82	....
			182				27.1	19.0	1.05	0.74	Deflection failure.†
								Ave........	0.98	0.77	
1919	Flat......		114	8.6	85	38.1	36.0	34.0	0.94	0.89	....
			116	9.6			34.0	32.5	0.89	0.85	....
			119	9.6			33.0	32.0	0.87	0.84	Deflection failure.
								Ave......	0.90	0.86	
1919	Flat......		115	18.0	85	34.7	33.9	32.0	0.98	0.92	....
			117				32.0	30.5	0.92	0.88	....
			118				31.0	29.3	0.89	0.84	Failed by buckling south and down.
								Ave........	0.93	0.88	
1919	Flat......		227	27.8	85	25.8	22.6	19.6	0.88	0.76	....
			228				23.0	20.0	0.89	0.77	....
			183				24.8	21.0	0.96	0.81	....
								Ave......	0.91	0.78	

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 1634.

† Indicated from photograph.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate. S'.	Column at U. L. P.. S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from Special Committee on Steel Columns and Struts Tests.*											
1919	Flat......		110	8.6	120	38.1	33.9	33.0	0.89	0.87	....
			111				31.0	30.2	0.81	0.79	....
			108				31.0	30.0	0.81	0.79	....
								Ave........	0.84	0.82	
1919	Flat......		109	17.8	120	34.7	30.0	29.0	0.86	0.84	....
			112				30.0	30.0	0.86	0.86	....
			113				30.0	29.0	0.86	0.84	....
								Ave........	0.86	0.85	
1919	Flat......		223	27.5	120	25.8	21.0	19.0	0.81	0.74	....
			224				21.0	18.5	0.81	0.72	....
			181				21.8	20.0	0.85	0.78	....
								Ave........	0.82	0.75	
1919	Flat......		6	11.7	50	36.3	35.7	29.9	0.98	0.82	Triple flexure.
			36				36.5	33.0	1.00	0.91	Triple flexure.
			75				38.6	33.0	1.06	0.91	....
								Ave........	1.01	0.88	

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 1634.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
					Data from Special Committee on Steel Columns and Struts Tests.*						
1919	Flat......		102	16.9	50	29.8	30.3	23.0	1.02	0.77	Buckled south and down.
			166				29.0	22.5	0.97	0.75	....
			169				28.0	22.0	0.94	0.74	....
								Ave........	0.98	0.75	
1919	Flat......		13	11.7	85	36.3	34.0	30.4	0.94	0.84	Triple flexure.
			79				33.9	31.5	0.93	0.87	Deflection failure.
			80				34.0	31.5	0.94	0.87	Deflection failure
								Ave........	0.94	0.86	
1919	Flat......		152	16.9	85	29.8	26.0	22.5	0.87	0.75	....
			153				26.4	23.5	0.88	0.79	....
			154				27.5	24.0	0.92	0.80	....
								Ave........	0.89	0.78	
1919	Flat......		26	11.7	120	36.3	32.0	30.3	0.88	0.83	....
			45				30.7	28.2	0.85	0.78	....
			49				33.1	31.6	0.91	0.87	....
								Ave........	0.88	0.83	

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 1634.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: Ultimate / Yield point $= \frac{S}{S_y}$	U. L. P. / Yield point $= \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from Special Committee on Steel Columns and Struts Tests.*											
1919	Flat		132	17.0	120	29.8	23.5	21.5	0.79	0.72	....
			133				23.9	22.0	0.80	0.74	....
			134				24.2	21.5	0.81	0.72	....
								Ave........	0.80	0.73	
1919	Flat		211	11.9	155	36.8	24.0	21.0	0.66	0.58	....
			212				23.2	23.0	0.64	0.63	....
			220				23.5	23.0	0.65	0.63	....
								Ave........	0.65	0.61	
1919	Flat		209	16.6	155	29.8	24.0	24.0	0.81	0.81	....
			210				23.0	23.0	0.77	0.77	....
			213				23.0	23.0	0.77	0.77	....
								Ave........	0.78	0.78	
1919	Flat		11	10.1	50	34.3	33.1	27.4	0.97	0.79	....
			41				34.0	28.2	0.99	0.82	Triple flexure.
			43				32.4	26.9	0.94	0.78	Buckled at center.
								Ave........	0.97	.80	

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 1634.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	STRENGTH, IN 1 000 LB. PER SQ. IN. OF: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	RATIO: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
DATA FROM SPECIAL COMMITTEE ON STEEL COLUMNS AND STRUTS TESTS.*											
1919	Flat		101 124 165	17.0	50	32.2	32.2 32.5 32.3	26.0 27.0 27.5	1.00 1.01 1.00	0.81 0.84 0.85	....
								Ave........	1.00	0.83	
1919	Flat		21 59 65	9.9	85	34.3,	33.7 32.3 31.7	29.2 28.4 28.6	0.98 0.94 0.92	0.85 0.83 0.83	Buckled at center. .... Deflection failure.
								Ave........	0.95	0.84	
1919	Flat		145 146 151	17.1	85	32.2	30.7 30.0 31.0	27.0 26.0 27.0	0.95 0.93 0.96	0.84 0.81 0.84	Buckled at center. ....
								Ave........	0.95	0.83	
1919	Flat		32 54 70	10.1	120	34.3	28.3 28.7 30.9	25.6 26.3 29.0	0.82 0.84 0.90	0.75 0.77 0.85	....
								Ave........	0.85	0.79	

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 1634.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from Special Committee on Steel Columns and Struts Tests.*											
1919	Flat		135	17.0	120	32.2	28.5	26.5	0.88	0.82	....
			136				28.8	26.5	0.89	0.82	....
			137				27.0	26.0	0.84	0.81	....
								Ave..........	0.87	0.82	
1919	Flat		215	10.4	155	34.3	26.1	25.7	0.76	0.75	....
			217				27.8	26.8	0.81	0.78	....
			221				25.6	24.7	0.75	0.72	....
								Ave..........	0.77	0.75	
1919	Flat		214	16.8	155	32.2	24.7	24.0	0.77	0.75	....
			216				25.0	23.0	0.78	0.71	....
			219				25.0	25.0	0.78	0.78	....
								Ave........	0.78	0.75	

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 1634.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: $\frac{\text{Ultimate}}{\text{Yield point}} = \frac{S'}{S_y}$	$\frac{\text{U. L. P.}}{\text{Yield point}} = \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Data from Special Committee on Steel Columns and Struts Tests.*											
1919	Flat	↓	1	8.7	50	35.9	33.8	28.3	0.94	0.79	Triple flexure.
			2				34.3	28.7	0.96	0.80	....
			42				34.3	27.9	0.96	0.78	....
								Ave.	0.95	0.79	
1919	Flat		14	8.7	85	35.9	32.5	26.9	0.91	0.72	Triple flexure.
			87				31.9	29.0	0.89	0.81	....
			88				32.9	28.0	0.92	0.78	....
								Ave.	0.91	0.77	
1919	Flat		24	8.7	120	35.9	30.6	27.9	0.85	0.78	....
			35				30.2	28.6	0.84	0.80	....
			47				30.0	27.5	0.84	0.77	....
								Ave.	0.84	0.78	

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 1634.

TABLE 1.—(*Continued.*)

Series.	End conditions.	Form of column.	Column no.	Area of section, in square inches.	$\frac{l}{r}$	Strength, in 1 000 Lb. per Sq. In. of: Metal at yield point, S_y.	Column at ultimate, S'.	Column at U. L. P., S''.	Ratios: Ultimate / Yield point $= \frac{S'}{S_y}$	U. L. P. / Yield point $= \frac{S''}{S_y}$	Remarks:
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
						Data from Kiel Ship Canal Bridge Tests.					
....	Pin........		I-1	63	51	31.2	29.6	....	0.95	....	....
			I-2	63	51	....	29.4	....	0.94	....	....
....	Pin........		II-1	70	58	34.0	32.8	....	0.96	....	....
			II-2	70	58	....	34.7	....	1.02	....	....
			III-1	70	58	34.0	33.2	....	0.98	....	....
			III-2	70	58	....	32.3	....	0.95	....	....
....	Pin........		IV	60	52	33.4	31.4	....	0.94	....	....
			V	60	52	....	31.2	....	0.93	....	....
....	Pin........		VI-1	64	51	37.6	36.4	....	0.97	....	....
			VI-2	64	51	....	37.4	....	0.99	....	....
....	Pin........		VII-1	64	51	40.5	34.5	....	0.85	....	....
			VII-2	64	51	....	38.5	....	0.95	....	....

The effect of $\frac{l}{r}$ is quite marked, and is fairly well indicated by the slope of the central line. The high values for $\frac{l}{r}$ less than 30 are due to the well-known behavior of very short compression members, and are of little significance in the consideration of the ordinary column.

Plate I (*B*) gives ratios of the U. L. P. of the column to the yield point of the metal for such tests as furnished the necessary information. Here, again, the general range is well shown by two straight lines. Comparing these results with those of Plate I (*A*), an important difference is seen to be in the flatter slope of the lines, showing a less effect of $\frac{l}{r}$, and the absence of any high results for small values of $\frac{l}{r}$. Comparing the center lines of the two diagrams, it is seen that for $\frac{l}{r} = 0$, they are 10% apart; whereas for $\frac{l}{r} = 100$, they are only 5% apart. That is, for short columns there is a greater margin between the U. L. P. and the ultimate strength than for long columns. This is what would be expected, and for $\frac{l}{r}$ as great as 155 (see Fig. 6), the ultimate strength and U. L. P. values are very nearly equal.

Another noteworthy feature of Plate I (*B*) is the very low values for some of the large built-up sections, all of which come well up among the general group in Plate I (*A*). This result is due to the shape of the stress-deformation curves of these columns from which the U. L. P.'s were determined. These curves show a comparatively low proportional elastic limit, with gradually increasing rate of deformation over a wide range of stress, so that the U. L. P., as defined by the Society's Special Committee on Steel Columns and Struts is low. An explanation of this behavior probably lies in the large number of parts of which the columns were composed, a condition which is apt to result in an appreciable amount of inelastic deformation at comparatively low loads, but with little influence on ultimate strength.

In Figs. 1, 2, 3, 4, and 5, the data shown on Plate I have been separated into groups for further study. In these diagrams, the upper and lower values are shown by the arrow-points and the average for the group by the plotted position of the column section. The sloping straight lines are the central lines from Plate I, drawn in as a guide for comparison.

Fig. 1 shows the tests of the Special Committee on Steel Columns and Struts. The ultimate ratios are rather high. Fig. 2 contains results on I and H-sections. The effect of form is hardly noticeable. Fig. 3 gives results on tubular columns. The range of ultimate values is naturally less than in the other groups on account of uniformity of material and form. There is no noticeable difference between pin and flat ends. Fig. 4 gives results for built-up latticed columns of all kinds, including the large columns reported in *Technologic Paper No. 101,* U. S. Bureau of Standards, and the Quebec Bridge

tests. Here, the ultimate strength ratio corresponds well with the others; but the U. L. P. ratio is low, as previously noted. Fig. 5 includes the tests on alloy steels of high elastic limit (up to a yield point of 60 000 lb. per sq. in.). The ultimate strength ratios correspond well with the general average; the U. L. P. ratios are low. As far as these tests are concerned, it would appear that for short columns the strength bears about the same relation to the yield point of the material as in the case of ordinary structural steel. Fig. 6 gives the results of the tests of the Society's Special Committee on Steel Columns and Struts in more detail, and up to $\frac{l}{r} = 155$. The heavy lines are rough average curves. Only those types are shown for which values of yield points were closely known. All lines tend to converge for increasing $\frac{l}{r}$, as is to be expected; for the column strength for high values of $\frac{l}{r}$ is more dependent on the modulus of elasticity, E, which is practically the same for all. Type 5, the solid H-section, shows up favorably; Type 2, the narrower box section, is about the best; Type 1, the I-section, is generally the poorest; Type 7, the bulb-angle section, is also rather poor. These relations correspond in general to the deductions in Part (B) of the detailed studies on component eccentricities. For the higher values of $\frac{l}{r}$, the range of variation becomes relatively small. Table 1 gives detailed results for all the columns used in these diagrams.

5.—The Yield Point Strength of the Metal.—The close relation between the strength of columns and the yield point strength of the material is obvious, and is well shown on the diagrams already discussed; but this relation, as shown by tests, does not appear to be as exact as it should be. This is due to several causes. One is the lack of reasonably exact information as to the material itself; and this is a very important factor in the whole problem of column strength. This kind of structural element is so sensitive to the effect of inelastic deformation, or over-strain, that it is especially important to know the practical elastic limit strength of the material out of which it is made. In the diagrams of Plate I, only those tests have been plotted for which the tensile yield points appeared to be fairly well known. In the case of the tests of the Special Committee on Steel Columns and Struts, these values were taken from the stress-strain diagrams prepared at the U. S. Bureau of Standards, and were generally from 1 500 to 2 000 lb. per sq. in. higher than the U. L. P.'s given in the report. In other cases, the statements made in the reports were taken at their face values and doubtless did not always accurately represent the material used. It is possible that some such point as the U. L. P. used by the Society's Special Committee on Steel Columns and Struts would be a more accurate reference point than the yield point, but as no other tests give this information, it seemed best to use the yield point instead, and it is believed that the diagrams represent fairly the relations indicated.

The difficulty of securing correct information regarding the elastic properties of the material actually used is well known. The values of yield point as

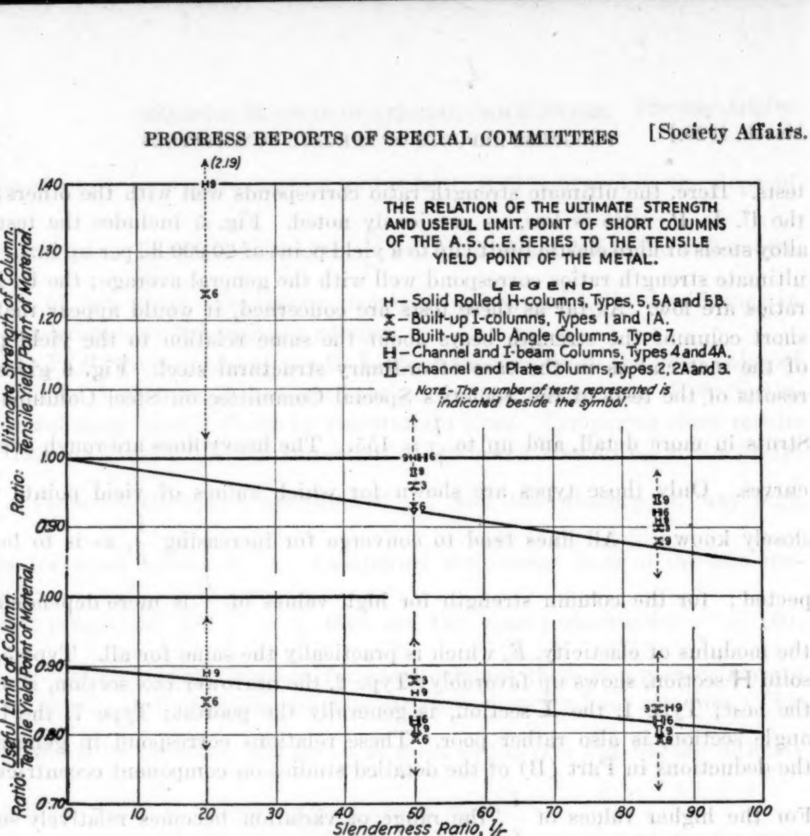

THE RELATION OF THE ULTIMATE STRENGTH AND USEFUL LIMIT POINT OF SHORT COLUMNS OF THE A.S.C.E. SERIES TO THE TENSILE YIELD POINT OF THE METAL.
LEGEND
H – Solid Rolled H-columns, Types 5, 5A and 5B.
X – Built-up I-columns, Types 1 and 1A.
X – Built-up Bulb Angle Columns, Type 7.
H – Channel and I-beam Columns, Types 4 and 4A.
II – Channel and Plate Columns, Types 2, 2A and 3.
Note - The number of tests represented is indicated beside the symbol.
Ratio: Ultimate Strength of Column / Tensile Yield Point of Material
Ratio: Useful Limit of Column / Tensile Yield Point of Material
Slenderness Ratio, l/r

FIG. 1.

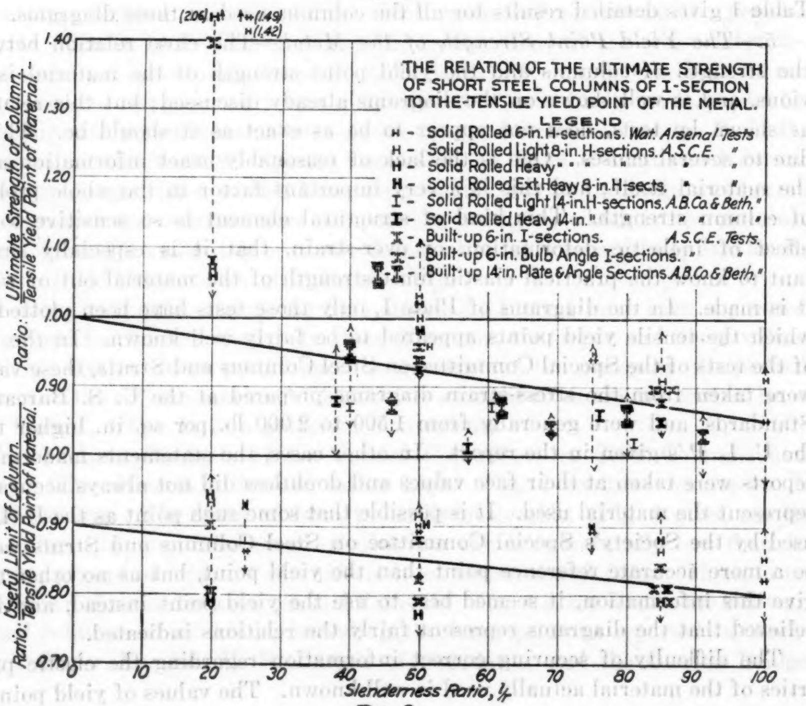

THE RELATION OF THE ULTIMATE STRENGTH OF SHORT STEEL COLUMNS OF I-SECTION TO THE TENSILE YIELD POINT OF THE METAL.
LEGEND
H - Solid Rolled 6-in. H-sections. Wat. Arsenal Tests
H - Solid Rolled Light 8-in. H-sections. A.S.C.E. "
H - Solid Rolled Heavy " " " "
H - Solid Rolled Ext. Heavy 8-in. H-sects. " "
I - Solid Rolled Light 14-in. H-sections. A.B.Co. & Beth."
I - Solid Rolled Heavy 14-in. " "
X - Built-up 6-in. I-sections. A.S.C.E. Tests.
X - Built-up 6-in. Bulb Angle I-sections.
I - Built-up 14-in. Plate & Angle Sections A.B.Co. & Beth."
Ratio: Ultimate Strength of Column / Tensile Yield Point of Material
Ratio: Useful Limit of Column / Tensile Yield Point of Material
Slenderness Ratio, l/r

FIG. 2.

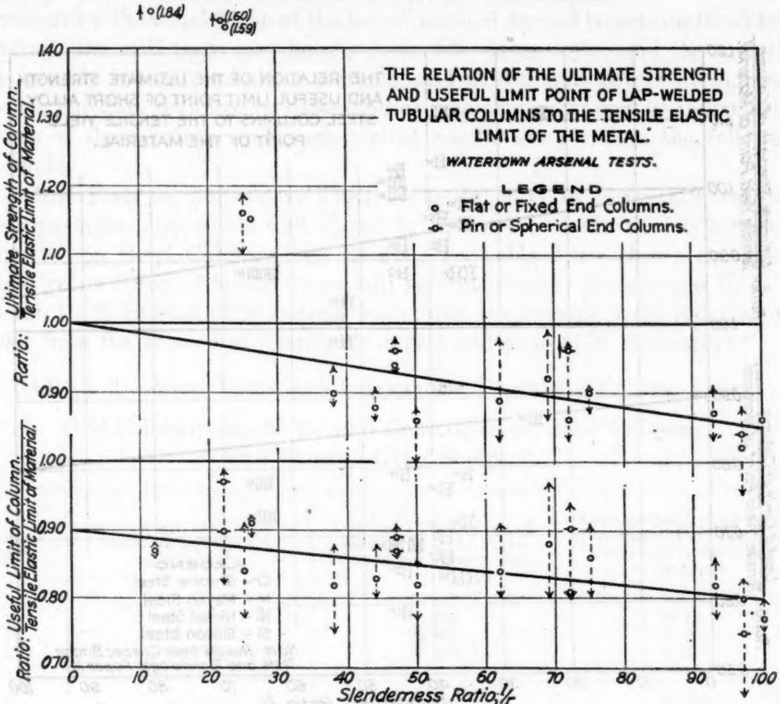

THE RELATION OF THE ULTIMATE STRENGTH AND USEFUL LIMIT POINT OF LAP-WELDED TUBULAR COLUMNS TO THE TENSILE ELASTIC LIMIT OF THE METAL.
WATERTOWN ARSENAL TESTS.
LEGEND
Flat or Fixed End Columns.
Pin or Spherical End Columns.
Ratio: Ultimate Strength of Column. / Tensile Elastic Limit of Material.
Ratio: Useful Limit of Column. / Tensile Elastic Limit of Material.
Slenderness Ratio, l/r

FIG. 3.

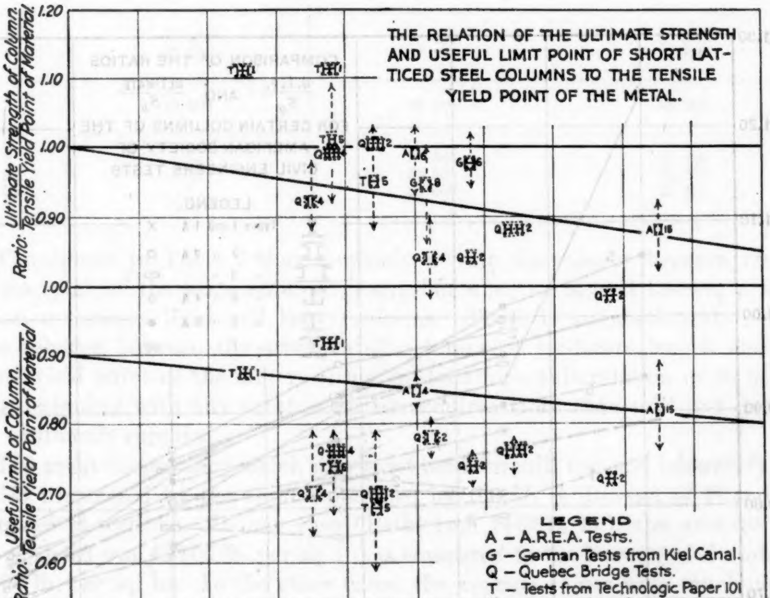

THE RELATION OF THE ULTIMATE STRENGTH AND USEFUL LIMIT POINT OF SHORT LATTICED STEEL COLUMNS TO THE TENSILE YIELD POINT OF THE METAL.
Ratio: Ultimate Strength of Column. / Tensile Yield Point of Material.
Ratio: Useful Limit of Column. / Tensile Yield Point of Material.
LEGEND
A – A.R.E.A. Tests.
G – German Tests from Kiel Canal.
Q – Quebec Bridge Tests.
T – Tests from Technologic Paper 101
Note: The number of tests represented is indicated beside the symbol.
Slenderness Ratio, l/r

FIG. 4.

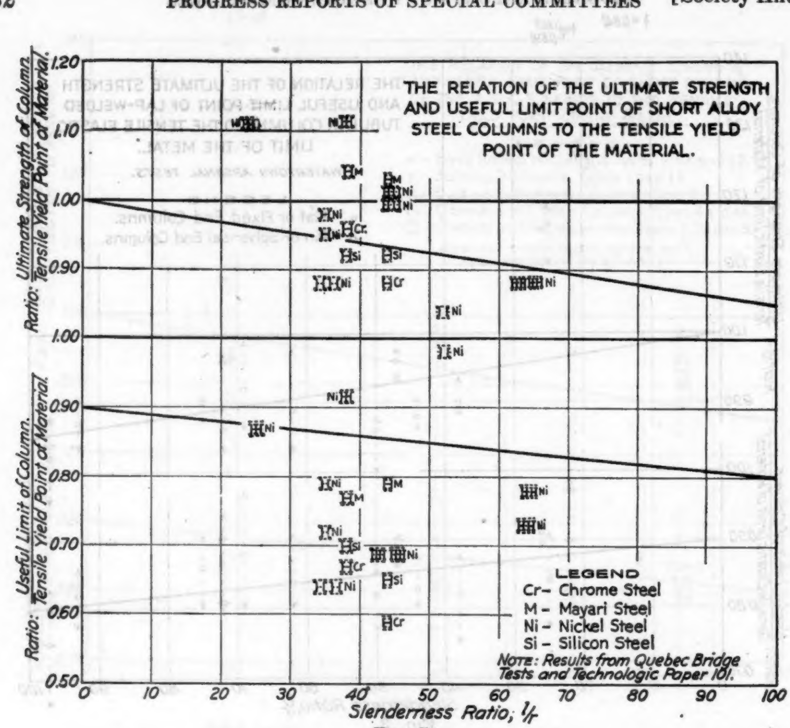

THE RELATION OF THE ULTIMATE STRENGTH AND USEFUL LIMIT POINT OF SHORT ALLOY STEEL COLUMNS TO THE TENSILE YIELD POINT OF THE MATERIAL.
Ratio: Ultimate Strength of Column / Tensile Yield Point of Material.
Ratio: Useful Limit of Column / Tensile Yield Point of Material.
LEGEND
Cr - Chrome Steel
M - Mayari Steel
Ni - Nickel Steel
Si - Silicon Steel
NOTE: Results from Quebec Bridge Tests and Technologic Paper 101.
Slenderness Ratio; l/r

FIG. 5.

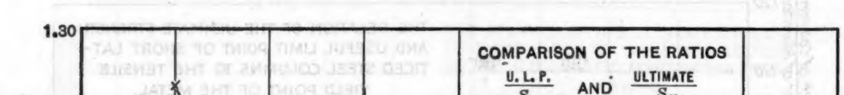

COMPARISON OF THE RATIOS U. L. P./S_y AND ULTIMATE/S_y FOR CERTAIN COLUMNS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS TESTS
LEGEND
Types 1 and 1 A
" 2 " 2 A
" 3 "
" 4 " 4 A
" 5 " 5 A
" 7
Ratio Ultimate Strength of Column / Tensile Yield Point
Ratio Useful Limit Point of Column / Tensile Yield Point
Slenderness Ratio $\frac{l}{r}$

FIG. 6.

determined by the usual "drop of the beam" method depend largely on the details of testing; the mill tests vary largely from laboratory tests; and the material varies greatly in thin and thick sections, and at different points in the same section. The data reviewed in these studies furnish a great deal of information on some of these points, and some typical results are given in the following paragraphs.

6.—Mill Tests vs. Laboratory Tests.—The difficulty in using mill test data for comparative purposes is well shown in the report of the Society's Special Committee on Steel Columns and Struts. In Table 2 are shown the values of yield point (drop of beam) from mill specimen tests; the average U. L. P. from the U. S. Bureau of Standards tests; and the average yield point as calculated from the Bureau of Standards curves and as used in this report.*

TABLE 2.—Mill Tests and Laboratory Tests for Elastic Limit.

(Final Report of the Special Committee on Steel Columns and Struts of the Society.)

Type of column.	Average mill test, drop of beam, in pounds per square inch.	Average U. S. Bureau of Standards U. L. P., in pounds per square inch.	Average yield point from U. S. Bureau of Standards curves, in pounds per square inch
1	34 000	33 100	35 100
1A	38 300	29 800	31 200
1B	36 400	31 100	32 500
2	36 500	32 500	34 300
2A	36 900	30 200	32 200
4	36 500	33 800	36 300
4A	37 700	27 100	29 800
7	34 600	33 500	35 000
5	......	37 500	38 100
5A	......	33 300	34 700
5B	......	22 600	25 800

The figures in Table 2 show not only a wide discrepancy between results for material of the same column group, but also, as is well known, a large variation between light and heavy sections. There is unquestionably a very close relation between the strength of columns of moderate length and the actual yield point of the material; but to determine this relation or to utilize it in designing with any great accuracy requires more than mill test data as now ordinarily supplied.

The great discrepancy which may exist between mill test and laboratory test is also illustrated by the results obtained by the U. S. Bureau of Standards on rolled H-sections. In one case (Bethlehem H-287½ lb.), the average mill test reported was 42 900 lb. per sq. in. as compared to the Bureau of Standards' 31 700 lb. per sq. in. In the other cases, the average values were much closer, generally not more than 2 000 lb. per sq. in. apart.

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919–20), p. 1629.

The difficulty of getting a proper average value even from coupons cut from the piece is not small. This is particularly true of such forms as the H-section. This was especially studied at the U. S. Bureau of Standards, where test specimens were cut from six different zones and a variation of from 35 000 to 45 000 lb. per sq. in. in yield point was found in one case. The tests of Marburg on I-beams* showed extreme variations in elastic limit (proportional), the value for material at the root being as low as 11 000 lb. per sq. in., and in several cases as low as 15 000 to 17 000 lb. At the same time the flanges showed about 25 000 lb. The yield points varied much less, the variation being generally only 3 000 to 4 000 lb. per sq. in. Moore† gives considerable data on beams, the variation of yield point in the same beam being commonly from 3 000 to 5 000 lb., and running as high as 15 000 lb. per sq. in., the large differences being due to especially high values of yield point for the flange material. Hancock‡ gives further data on the same subject. Considering the effect of variation of material across the section, it would appear that the value of the minimum yield point would have a great effect on the strength of the column, and that perhaps a rating based on minimum yield point would be the most significant; but so far as the Committee has been able to observe, the average value is better. No doubt a very low yield point of the material making up the flange of a column would seriously affect its strength, but flange material of any form is not likely to be of a particularly low value, and the difficulty of determining the properties of the actual components of a member make it very doubtful whether anything would be gained by attempting to use minimum rather than average values.

7.—*Tensile vs. Compressive Yield Point of Test Specimens.*—In the foregoing discussion, the tensile yield point of the material has been used in all cases. It is seldom that information is given côncerning the compressive yield points, and it is doubtful whether it will be found practicable to secure such information in general if the tensile yield point gives satisfactory results; but, undoubtedly, the compressive yield point is, after all, the significant thing, and it is desirable to compare the two values as far as possible. The tests of the U. S. Bureau of Standards for the Society's Special Committee on Steel Columns and Struts give some information on this point. Table 3 shows the U. L. P. from tension and compression tests of some of the material used. Average values are given in each case. The values of $\frac{l}{r}$ ranged from 12 to 20.

Considerable other information exists regarding the relation of elastic properties from tensile and compressive tests. Marshall's experiments§ on mild steel show slightly higher values of elastic limit in compression than in tension, the average being about $2\frac{1}{2}$ per cent. Seeley and Putnam‖ give the average results from a considerable number of tests shown in Table 4.

* *Proceedings,* Am. Soc. for Testing Materials, 1909.
† *Loc. cit.,* 1910.
‡ *Loc. cit.,* 1911.
§ *Transactions,* Am. Soc. C. E., Vol. XVII (1887), p. 54.
‖ *Bulletin No. 115,* Eng. Experiment Station, Univ. of Illinois, 1919.

TABLE 3.—COMPARISON OF TENSILE AND COMPRESSIVE USEFUL LIMIT POINTS.
(From Final Report of Society's Special Committee on Steel Columns and Struts.)

Type of column.	Test specimen.	Average U. L. P., tension, in pounds per square inch.	Average U. L. P., compression, in pounds per square inch.	Ratio: Tension / Compression.
1	5 by 3 by 5/16-in. angle	33 300	33 100	1.006
	6 by 5/16-in. plate	32 300	29 800	1.08
1 A	5 by 3 by 5/8-in. angle	29 800	27 000	1.11
2	8 by 1/4-in. plate	31 500	28 200	1.12
	6-in. channel	33 200	34 000	0.98
3	5-in. channel	34 100	35 200	0.97
4	8-in. channel	34 700	36 100	0.96
	8-in. I-beam	34 500	30 800	1.12
4 A	8-in. channel	26 100	28 600	0.91
	8-in. I-beam	28 000	28 400	0.99

Results of tests on normal and heat-treated steels with ultimate strengths from 42 400 to 138 000 lb. per sq. in. by Moore and Kommers* gave values for ratio of tensile to compressive yield points ranging from 92 to 116%, and averaging about 101 per cent. These included nickel and chrome steels.

TABLE 4.—AVERAGE RESULTS FROM TESTS ON THE RELATION OF ELASTIC PROPERTIES OF VARIOUS KINDS OF STEEL.

Material.	Tension, ultimate, in pounds per square inch.	RATIO: TENSILE TO COMPRESSIVE.		
		Proportional limit.	U. L. P.	Yield point.
Soft steel	55 400	0.784	0.933	1.01
Mild steel	54 900	0.943	.....	.....
Medium steel	78 000	0.99	1.01	0.965
Vanadium steel	109 000	0.950	0.972	0.943
Nickel steel:				
(a). Parallel to rolling	87 900	0.939	0.923	0.956
(b). Perpendicular to rolling	87 700	1.00	0.985	0.972
Chrome nickel steel	65 600	0.886	0.887	0.942

In general, it would appear that the tensile yield point is a close indication of the compressive yield point, and for the purpose in question probably as satisfactory an indication of column strength. An examination of the column test results of the Society's Special Committee on Steel Columns and Struts shows no closer relation to the compressive than to the tensile yield point.

8.—*Yield Point Determined by Tests on Short Column Sections.*—It has been proposed to make use of short sections of actual columns for the purpose of determining the elastic properties of the combination of shapes used and to base estimates of column strengths upon such information. This is a logical process, and should give superior results. It is doubtful, however, whether such a method is practicable in general. As a matter of fact, the results of the tests made by the Society's Special Committee on Steel Columns and Struts,

* *Bulletin No. 124*, Eng. Experiment Station, Univ. of Illinois, 1921.

when measured by the useful limit values from the tests on the very short test pieces $\left(\frac{l}{r} = 20\right)$, show a greater variation than when referred to the average yield point of the material. This is hardly sufficient evidence to condemn this method, but it throws doubt on its special value.

(B) Results of Tests on Columns of All Lengths and Showing Integral Action

9.—There have been assembled in Figs. 7, 8, and 9 the results of all available tests which appear to be pertinent to the present investigation. Tests have been excluded where failure was due to weak details, or where the load was applied eccentrically. The complete list of tests is given herewith, and for the full test data, the reader is referred to the original articles:

Steel Columns.—

American Railway Engineering Association. 30 tests. Latticed channel columns tested at the U. S. Bureau of Standards. Columns with batten-plate connections omitted. (*Proceedings,* Am. Ry. Eng. Assoc., Vol. 16, p. 636; Vol. 19, p. 789).

American Society of Civil Engineers. 99 tests. Tested by the U. S. Bureau of Standards. The following tests are omitted because of unknown or uncertain yield point of material: No. 3 heavy; No. 6; No. 6A; No. 8; No. 8A; Z-bar; No. 10 heavy; and the Carnegie H-columns; also, No. 5, extra heavy for $\frac{l}{r} = 20$. (*Transactions,* Am. Soc. C. E., Vol. LXXXIII, (1919-20), p. 1583).

American Bridge Company and Bethlehem Steel Company. 69 tests. Tested at the U. S. Bureau of Standards. Report to be published.

Watertown Arsenal Tests of H-Sections and Built-Up I-Sections. 130 tests. Two omitted on account of excessive bends. 94 tests of lap-welded tubing; 12 omitted for $\frac{l}{r} = 12$ to 22. (Report on Tests of Metals and Other Materials, 1908, 1909, 1910, 1912, 1913, 1914).

Waddell's Tests on Built-Up Channel Sections. 12 tests. (*Transactions,* Am. Soc. C. E., Vol. LXIII, (1909), p. 246).

Buchanan's Tests on Built-Up I- and Plate- and Channel-Sections. 6 tests. Six omitted on account of eccentric loading or failure of details. (*Engineering News,* Vol. 58, p. 685).

Christie's Tests on Small Angle-Sections. 16 tests. Used only tests for $\frac{l}{r} = 160$ to 300. (*Transactions,* Am. Soc. C. E., Vol. XIII, (1884), p. 253).

Kiel Canal Bridge. Built-Up Channel Sections. 12 tests. (*Engineering News-Record,* Vol. 88, p. 877).

Tests on Large Built-Up Columns, U. S. Bureau of Standards. 10 tests. Omitted 2 tests on account of high yield point of material and 6 tests on account of failure in details. (*Technologic Paper No. 101,* U. S. Bureau of Standards).

Quebec Bridge Tests. 18 tests. Omitted 2 tests on account of high yield point of material and others that were tested horizontally

without counterpoise. (The Quebec Bridge, 1919, Department of Railways and Canals, Canada; also *Engineering Record*, Vol. 62, p. 564; Vol. 69, p. 333).

Wrought-Iron Columns.—

Bouscaren's Tests. 16 tests. Tests on Keystone and old American Bridge Company's sections omitted. (*Transactions*, Am. Soc. C. E., Vol. IX, (1880), p. 447).

Christie's Tests on Small Shapes. Used results for $\frac{l}{r} = 160$ to 300. (*Transactions*, Am. Soc. C. E., Vol. XIII, (1884), p. 85).

Buchanan's Tests. 2 tests. Omitted others which failed in details. (*Engineering News*, Vol. 58, p. 685).

Clark Reeves and Company. Phœnix Columns. Omitted 2, $\frac{l}{r} = 2.7$. (Report of Tests of Metals and Other Materials, 1881, p. 263).

Strobel's Tests on Z-Bar Columns. 15 tests. (*Transactions*, Am. Soc. C. E., Vol. XVIII, (1888), p. 103).

Watertown Arsenal. 190 tests. Omitted 13 because of eccentric loads or failure in details. Omitted 3 because of excessive bends. (Report on Tests of Metals and Other Materials, 1881, 1882, 1883, 1884).

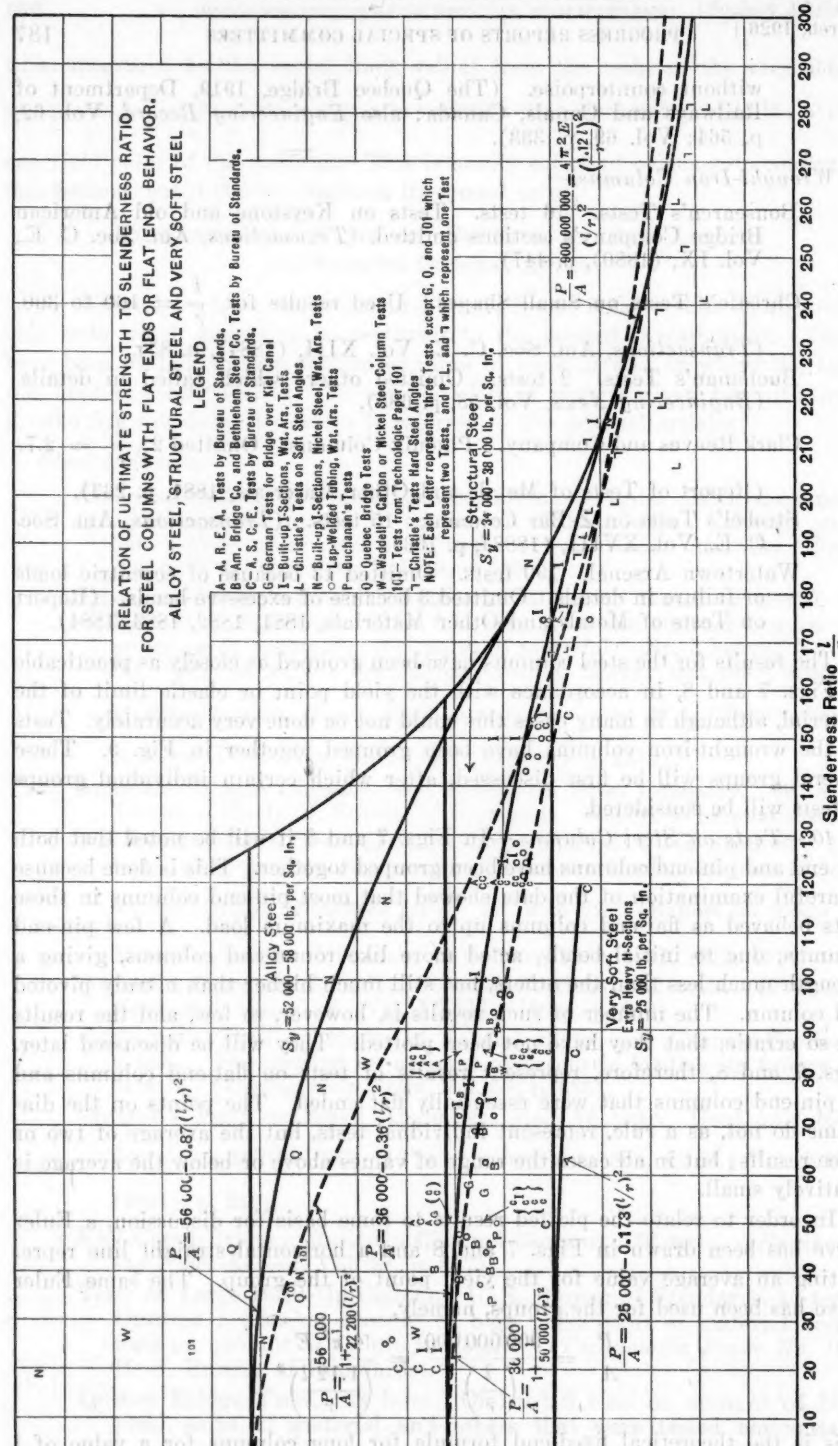
The results for the steel columns have been grouped as closely as practicable in Figs. 7 and 8, in accordance with the yield point or elastic limit of the material, although in many cases this could not be done very accurately. Tests on the wrought-iron columns have been grouped together in Fig. 9. These general groups will be first discussed, after which certain individual groups of tests will be considered.

10.—Tests on Steel Columns.—In Figs. 7 and 8 it will be noted that both flat-end and pin-end columns have been grouped together. This is done because a careful examination of the data showed that most pin-end columns in these tests behaved as flat-end columns up to the maximum load. A few pin-end columns, due to initial bends, acted more like round-end columns, giving a strength much less than the others, but still much higher than a truly pivoted end column. The number of such results is, however, so few, and the results are so erratic, that they have not been plotted. They will be discussed later. Figs. 7 and 8, therefore, represent results of tests on flat-end columns and on pin-end columns that were essentially flat ended. The points on the diagrams do not, as a rule, represent individual tests, but the average of two or three results; but in all cases the range of values above or below the average is relatively small.

In order to relate the plotted results to some basis for discussion, a Euler curve has been drawn in Figs. 7 and 8 and a horizontal straight line representing an average value for the yield point of the group. The same Euler curve has been used for the groups, namely,

$$\frac{P}{A} = \frac{900\,000\,000}{\left(\frac{l}{r}\right)^2} = \frac{4\,\pi^2 E}{\left(\frac{1.12\,l}{r}\right)^2}$$

This is the theoretical fixed-end formula for long columns for a value of l



RELATION OF ULTIMATE STRENGTH TO SLENDERNESS RATIO
FOR STEEL COLUMNS WITH FLAT ENDS OR FLAT END BEHAVIOR.
ALLOY STEEL, STRUCTURAL STEEL AND VERY SOFT STEEL
LEGEND
A—A. R. E. A. Tests by Bureau of Standards.
B—Am. Bridge Co. and Bethlehem Steel Co. Tests by Bureau of Standards.
C—A. S. C. E. Tests by Bureau of Standards.
G—German Tests for Bridge over Kiel Canal
I—Built-up I-Sections, Wat. Ars. Tests
L—Christie's Tests on Soft Steel Angles
N—Built-up I-Sections, Nickel Steel, Wat. Ars. Tests
O—Lap-Welded Tubing, Wat. Ars. Tests
P—Buchanan's Tests
Q—Quebec Bridge Tests
W—Waddell's Carbon or Nickel Steel Column Tests
101—Tests from Technologic Paper 101
ᒣ—Christie's Tests Hard Steel Angles
NOTE: Each Letter represents three Tests, except G, Q, and 101 which represent two Tests, and P, L, and ᒣ which represent one Test
Alloy Steel
$S_y = 52\,000-58\,000$ lb. per Sq. In.
Structural Steel
$S_y = 34\,000-38\,000$ lb. per Sq. In.
Very Soft Steel
Extra Heavy H-Sections
$S_y = 25\,000$ lb. per Sq. In.
$\frac{P}{A} = 56\,000 - 0.87\,(l/r)^2$
$\frac{P}{A} = \frac{56\,000}{1+\frac{1}{22\,200}(l/r)^2}$
$\frac{P}{A} = 36\,000 - 0.36\,(l/r)^2$
$\frac{P}{A} = \frac{36\,000}{1+\frac{1}{50\,000}(l/r)^2}$
$\frac{P}{A} = 25\,000 - 0.173\,(l/r)^2$
$\frac{P}{A} = \frac{900\,000\,000}{(l/r)^2} = \frac{4\,\pi^2 E}{\left(\frac{1.12\,l}{r}\right)^2}$
Ultimate Strength, $\frac{P}{A}$, in Thousands of Pounds per Square Inch
Slenderness Ratio $\frac{l}{r}$
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300

FIG. 7.

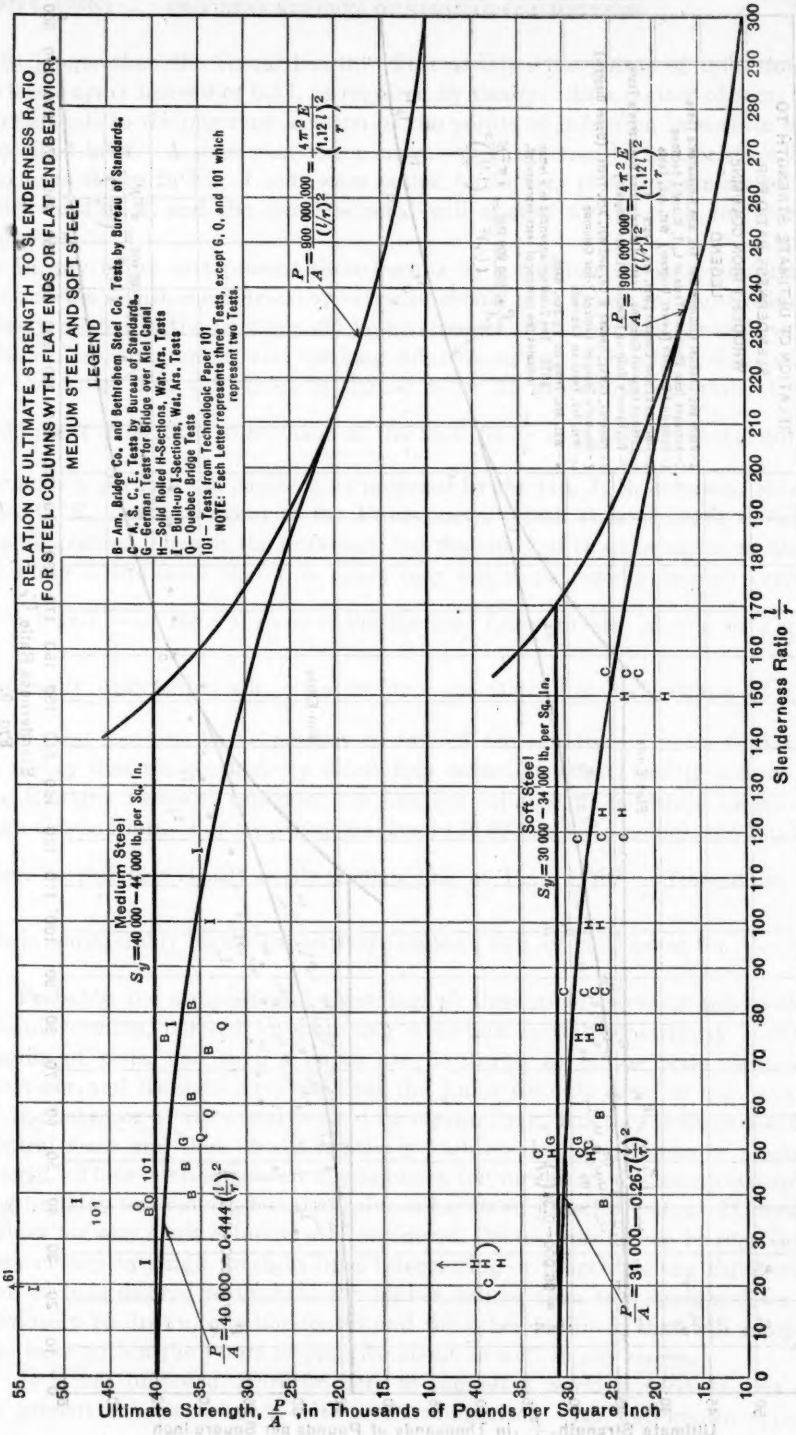

RELATION OF ULTIMATE STRENGTH TO SLENDERNESS RATIO
FOR STEEL COLUMNS WITH FLAT ENDS OR FLAT END BEHAVIOR.
MEDIUM STEEL AND SOFT STEEL
LEGEND
B – Am. Bridge Co. and Bethlehem Steel Co. Tests by Bureau of Standards.
C – A. S. C. E. Tests by Bureau of Standards.
G – German Tests for Bridge over Kiel Canal
H – Solid Rolled H-Sections, Wat. Ars. Tests
I – Built-up I-Sections, Wat. Ars. Tests
Q – Quebec Bridge Tests
101 – Tests from Technologic Paper 101
NOTE: Each Letter represents three Tests, except G, Q, and 101 which represent two Tests.
Medium Steel
$S_y = 40\,000 - 44\,000$ lb. per Sq. In.
Soft Steel
$S_y = 30\,000 - 34\,000$ lb. per Sq. In.
$\frac{P}{A} = 40\,000 - 0.444\left(\frac{l}{r}\right)^2$
$\frac{P}{A} = 31\,000 - 0.267\left(\frac{l}{r}\right)^2$
$\frac{P}{A} = \frac{900\,000\,000}{(l/r)^2} = \frac{4\pi^2 E}{\left(\frac{1.12\,l}{r}\right)^2}$
Slenderness Ratio $\frac{l}{r}$
Ultimate Strength, $\frac{P}{A}$, in Thousands of Pounds per Square Inch

FIG. 8.

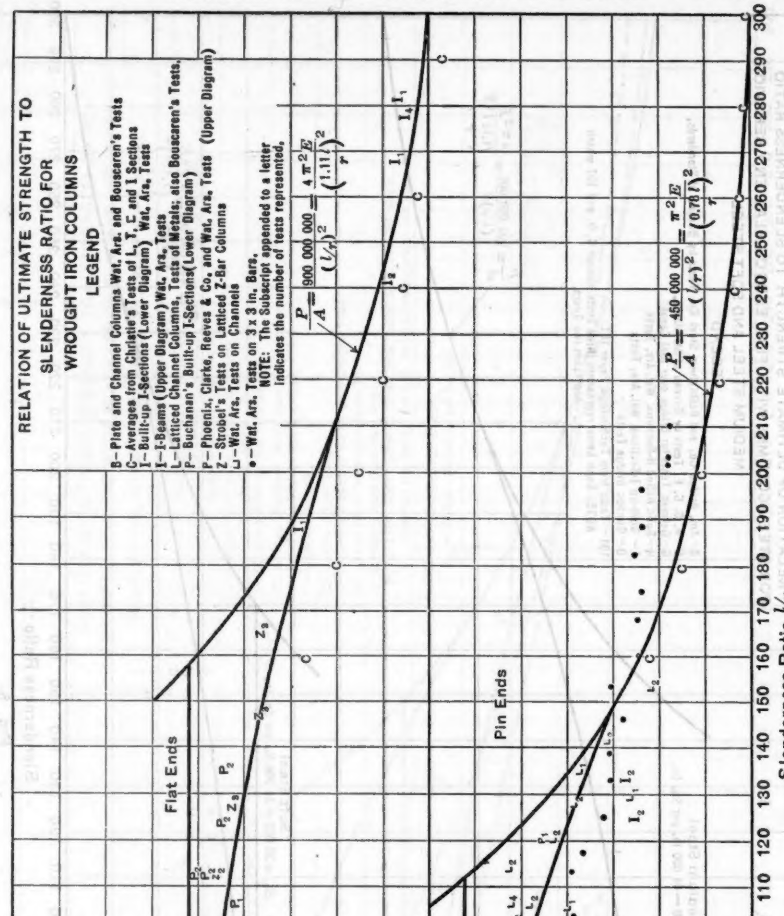

RELATION OF ULTIMATE STRENGTH TO SLENDERNESS RATIO FOR WROUGHT IRON COLUMNS
LEGEND
B – Plate and Channel Columns Wat. Ars. and Bouscaren's Tests
C – Averages from Christie's Tests of L, T, C and I Sections
I – Built-up I-Sections (Lower Diagram) Wat. Ars. Tests
I – I-Beams (Upper Diagram) Wat. Ars. Tests
L – Latticed Channel Columns, Tests of Metals; also Bouscaren's Tests.
P – Buchanan's Built-up I-Sections (Lower Diagram)
P – Phoenix, Clarke, Reeves & Co. and Wat. Ars. Tests (Upper Diagram)
Z – Strobel's Tests on Latticed Z-Bar Columns
ꓵ – Wat. Ars. Tests on Channels
• – Wat. Ars. Tests on 3 x 3 in. Bars.
NOTE: The Subscript appended to a letter indicates the number of tests represented.
Flat Ends
Pin Ends
$\frac{P}{A} = 36\,000 - 0.36\left(\frac{l}{r}\right)^2$
$\frac{P}{A} = 36\,000 - 0.72\left(\frac{l}{r}\right)^2$
$\frac{P}{A} = \frac{900\,000\,000}{(l/r)^2} = \frac{4\pi^2 E}{\left(\frac{1.11\,l}{r}\right)^2}$
$\frac{P}{A} = \frac{450\,000\,000}{(l/r)^2} = \frac{\pi^2 E}{\left(\frac{0.78\,l}{r}\right)^2}$
Slenderness Ratio l/r
Ultimate Strength, $\frac{P}{A}$, in Thousands of Pounds per Square Inch

FIG. 9.

12% longer than the actual length. This assumes the points of inflection to be 0.56 l apart instead of 0.5 l, as required by theory. As a matter of fact, this corresponds to the observed location of the points of inflection in certain tests described later. A somewhat lower curve would apparently fit Christie's flat-end tests shown in Fig. 7 somewhat better, but a very close agreement will be noted in Fig. 9, and the curve selected will answer well enough for present purposes.

In any effort to represent these results by a formula, it is apparent that such formula, either empirical or rational, should give values for short columns closely related to the tensile yield point strength of the material, which varies with different materials, and for long columns values approaching those given by the Euler law, and which is the same for all grades of material. If the yield point strength is to be taken as the limit for $\frac{l}{r} = 0$, the simplest empirical formula is perhaps the parabola as proposed by the late J. B. Johnson, M. Am. Soc. C. E., drawn tangent to the Euler curve. Such parabolas are shown in the diagrams. They fit the tests well, but the study of short columns, as shown in Plate I, indicates that this curve may not slope rapidly enough between $\frac{l}{r} = 0$ and $\frac{l}{r} = 100$. Curves of the Rankine form are also shown in Fig. 7, arbitrarily drawn through $\frac{P}{A} = 20$ for $\frac{l}{r} = 200$. For high values of yield point, the Rankine curve appears to fall off too rapidly. This is equivalent to saying that the eccentricity (including deflection effect) tacitly assumed in the Rankine formula, increases too fast for columns of moderate length and high elastic limit. For the structural steel (36 000 lb. yield point), the Rankine curve corresponds closely to the median line of Plate I for $\frac{l}{r}$ from 80 to 100, but is considerably higher for shorter lengths $\left(95\% \text{ of yield point for } \frac{l}{r} = 50\right)$.

Probably the simplest and most logical theoretical curve is the so-called secant formula, derived by assuming a certain initial eccentricity based on results of tests, and such a curve can be drawn to fit the tests quite well. Engesser and Karman have modified the Euler formula so as to take account of the behavior of the metal beyond its elastic limit, but they assume perfectly central loads and thus obtain relatively high results for columns of moderate length. Their curves show an upward turn for very short columns, corresponding to many test results, but this point is hardly of practical value. If the high values for very short columns are considered, the test results can be represented very closely by single straight lines intersecting or tangent to the Euler curve, and if it is desired to exclude the higher values, then two straight lines can obviously be drawn, one horizontal and the other inclined, that will represent the tests within the range of practice about as well as any curve.

It is not proposed, however, here to suggest a working formula, but only to present the test records with some comparison with well-known types of

formulas. The tests shown in Figs. 7 and 8 are for flat-end conditions, and can hardly be applied to columns in structures. This subject is reserved for discussion in a later report.

11.—Tests on Wrought-Iron Columns.—Fig. 9 shows results of tests on wrought-iron columns. Here the pin-end tests show a greater variation from the flat-end tests than in the case of the steel columns, and are plotted in a separate group, and a different Euler curve is drawn. Greater differences in straightness and in pin friction are doubtless the cause of so wide a variation in results. A straight line seems to fit these results as well as any curve.

*12.—Watertown Arsenal Tests on Steel Built-Up I-Columns.**—These tests included the variables given in Table 5.

TABLE 5.

Nominal tensile strength of metal, in pounds per square inch.	Number of columns tested.	Kind of ends.†	Range in $\frac{l}{r}$.‡	Dimensions, in Inches. Web-plate.	Four angles.	Section. Width.	Section. Depth.	Nominal area, in square inches.	Least radius of gyration, in inches.
55 000 to	21	Flat	25 to	10 by ⅜	4 by 3 by ⅜	8⅜	10¼	13.7	1.65
65 000	21	Pin	175	10 by ⅜	4 by 3 by ⅜	8⅜	10¼	13.7	1.65
90 000*	6	Flat	25 and	10 by ⅜	4 by 3 by ⅜	8⅜	10¼	13.7	1.65
70 000	6	Flat	100	10 by ⅜	4 by 3 by ⅜	8⅜	10¼	13.7	1.65
60 000	15	Pin	19 to 214	6 by ⅜	2½ by 2½ by ⅜	5⅜	6¼	9.17	1.05
70 000	12	Pin	19 to 116	6 by ⅜	2½ by 2½ by ⅜	5⅜	6¼	9.17	1.05
90 000*	17	Pin	19 to 214	6 by ⅜	2½ by 2½ by ⅜	5⅜	6¼	9.17	1.05

* Nickel steel.

† Where pins were used; they were placed with their axes in the plane of the column web.

‡ Based on length between centers of pins. Pins were 3 in. in diameter.

The results of these tests are plotted in Fig. 10, the points representing generally the average of three tests.

Here, again, it will be observed that the end conditions affected the strengths very little. The pin-end columns of 60 000-lb. steel with a slenderness ratio of 25, were slightly stronger than the corresponding flat-end columns; with $\frac{l}{r}$ greater than 125, the pin ends were somewhat weaker than the flat ends.

Considering columns of 60 000-lb. steel, it appears that:

(*a*).—Flat-end columns with $\frac{l}{r} = 25$ failed by buckling of the flanges. Longer members failed by triple flexure in a plane normal to the web-plate. Sudden springing laterally occurred in tests of columns with $\frac{l}{r} = 125$, or more, when the maximum load was reached.

(*b*).—The larger sections with pin ends and $\frac{l}{r} = 25$ failed by buckling of the flanges; with $\frac{l}{r} = 50$, by triple flexure and buckling of the flanges; with

* Report on Tests of Metals and Other Materials, 1909–14.

$\frac{l}{r}$ greater than 50, by deflection normal to the web. The smaller sections with pin ends and $\frac{l}{r} = 19$ failed by buckling of web and flanges; with $\frac{l}{r} = 39$ or greater, by deflection normal to pins. Pin-end columns with $\frac{l}{r} = 100$, or greater, exhibited sudden lateral springing at the maximum load.

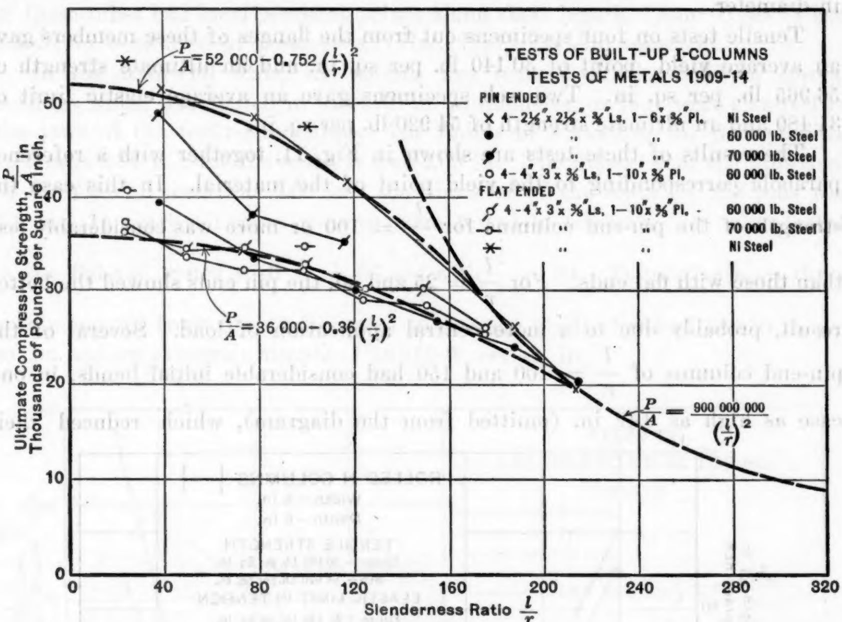


FIG. 10.

(c).—As in the tests on tubes and solid-rolled H-columns, so in these tests the pin friction was sufficient in most cases to prevent rotation of the ends of the columns under inherent eccentricities of load. Certain of the longer pin-end columns had initial bends which had an effect sufficient to offset the pin friction.

From the diagram (Fig. 10) it will be noted that the strength of the short lengths, $\frac{l}{r} = 25$ or less, did not run as high as in some other forms. For these short lengths, failure occurred by buckling of the flanges. The ratio of unsupported width to thickness was 10.7 : 1. For purposes of comparison, there have been drawn, on the diagram, the same Euler curve as in Fig. 7, and also tangent parabolas applicable to the 60 000-lb. steel and the nickel steel. The results on the 70 000-lb. steel are not sufficiently numerous to warrant separate consideration. The manner in which the strength of the nickel-steel column approaches that of the structural steel at high values of $\frac{l}{r}$, is quite striking.

13.—Tests on Solid Rolled **H**-*Columns*.*—Results of tests on eighteen solid-rolled **H**-sections with flat ends and a like number with pin ends are given in the two reports referred to. These **H**-sections had flanges 6 in. wide, varying in thickness from $\frac{7}{16}$ in. at the edges to $\frac{1}{2}$ in. near the webs. They were 6 in. deep, and had webs $\frac{1}{2}$ in. thick. The area of cross-section was 7 sq. in., and the least radius of gyration was 1.54 in. Tests were made in triplicate for six lengths, ranging between 3 ft. $2\frac{1}{2}$ in. and 19 ft. 3 in. The pins were 3 in. in diameter.

Tensile tests on four specimens cut from the flanges of these members gave an average yield point of 30 140 lb. per sq. in. and an ultimate strength of 56 965 lb. per sq. in. Two web specimens gave an average elastic limit of 31 480 and an ultimate strength of 54 920 lb. per sq. in.

The results of these tests are shown in Fig. 11, together with a reference parabola corresponding to the yield point of the material. In this case the strength of the pin-end columns for $\frac{l}{r} = 100$ or more was considerably less than those with flat ends. For $\frac{l}{r} = 25$ and 50, the pin ends showed the better result, probably due to a more central application of load. Several of the pin-end columns of $\frac{l}{r} = 100$ and 150 had considerable initial bends, in one case as high as 0.42 in. (omitted from the diagram), which reduced their

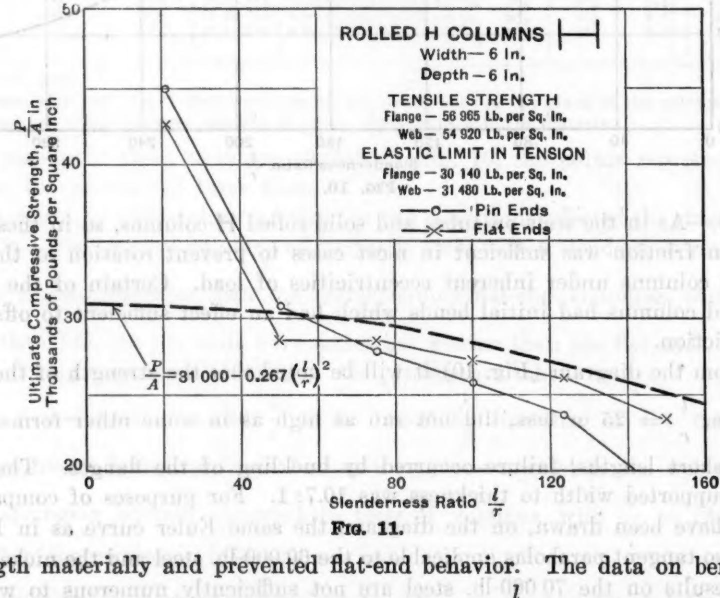


FIG. 11.

strength materially and prevented flat-end behavior. The data on bends are discussed later. It will be noted that the values for $\frac{l}{r} = 25$ show in a marked degree the excess strength for very short columns, and quite unlike the results shown in Fig. 10. This difference is probably due in large measure to the

* Reports on Tests of Metals and Other Materials, 1908–09.

thicker flange in the **H**-section, the ratio of unsupported width to the thickness being about 6, as compared to 10.7 in the case of the weaker built-up **I**-sections of Fig. 9.

*14.—Tests on Bessemer Steel Lap-Welded Tubing.**—One hundred and six tests on tubing, 5 in. in outside diameter, with a nominal thickness of 0.36 in., nominal area of cross-section of 5.25 sq. in., and radius of gyration of 1.645 in., were made at the Watertown Arsenal. The lengths of the specimens ranged from 1 ft. $8\frac{9}{16}$ in. to 24 ft. The slenderness ratio varied from 12.5 to 175. Most of these tubes had local bends at points along their length. Four types of end condition were used in these tests: Flat, fixed, pin, and spherical.

In the fixed-end tests, the tubing was secured at the ends in special castings which terminated in bases 18 in. in diameter, or they were clamped in the jaws of the testing machine. The radius of curvature for the spherical ends was 2.75 in.; for the seats, it was 3.00 in. The diameter of the pins used in the pin-end tests was 3.00 in.; the diameter of the seats for the pins was $3\frac{1}{64}$ in. In nearly all cases columns were tested in triplicate; six were tested in the flat-end series with $\frac{l}{r} = 25$ and with $\frac{l}{r} = 50$. Tensile tests on three specimens cut from these tubes gave an average elastic limit of 36 250 lb. per sq. in. and an average ultimate of 58 310 lb. per sq. in.

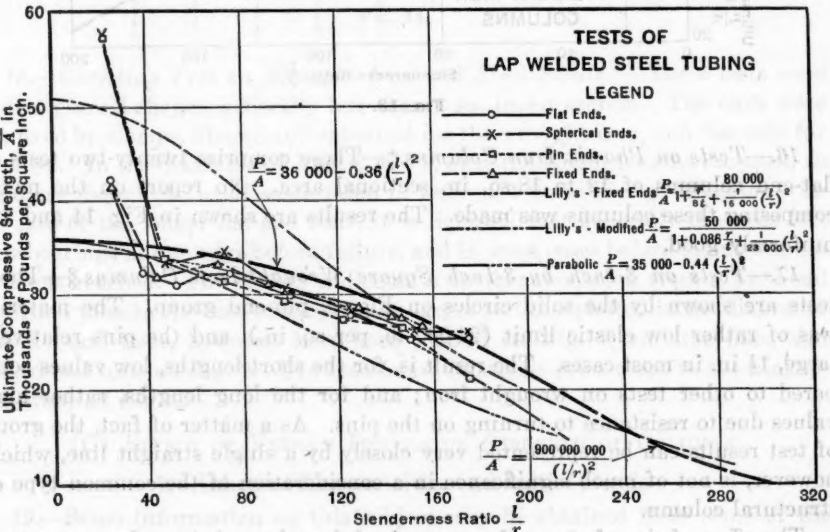


FIG. 12.

The results of these tests are shown in Fig. 12. Here, again, there is very little difference in results for different end conditions, except for the very short lengths, where the pin and spherical ends give the best results, and for the longest specimens, where the flat and fixed ends show best. Several curves are

* Reports on Tests of Metals and Other Materials, 1908–09.

shown in this diagram: The formula (upper curve) proposed by Lilly* for steel tubing; a modified Lilly formula; a parabola, $\frac{P}{A} = 35\,000 - 0.44 \left(\frac{l}{r}\right)^2$; and the same parabola and Euler curve as shown in Fig. 7. The Lilly formula is of the Rankine type with special constants. A parabola, or, within certain limits, a straight line, appears to fit these tests satisfactorily.

15.—Strobel's Tests on Z-Bar Iron Columns.†—These consisted of tests on fifteen flat-end columns varying in sectional area from 9 to 10 sq. in. The average yield point of material was 34 200 lb. per sq. in. All columns failed as a unit and the results of tests in duplicate and triplicate were concordant. They are shown in Fig. 13 with the same parabola as that used in Fig. 7. Considering the relatively low yield point, the results may be considered as rather superior to those obtained on some of the other forms.

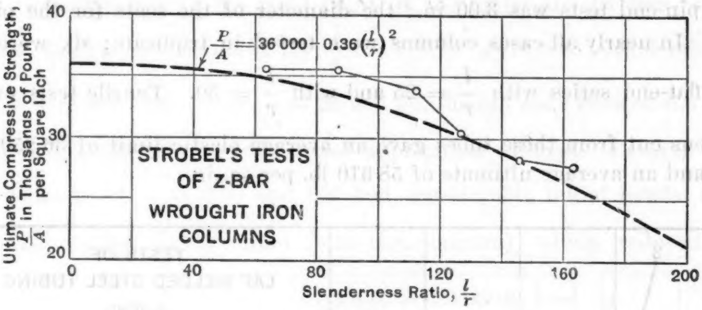


FIG. 13.

16.—Tests on Phœnix Iron Columns.‡—These comprise twenty-two tests of flat-end columns of 12 to 18-sq. in. sectional area. No report on the metal composing these columns was made. The results are shown in Fig. 14 and are uniformly good.

17.—Tests on 3-Inch by 3-Inch Square Wrought-Iron Columns.§—These tests are shown by the solid circles on Fig. 9, pin-end group. The material was of rather low elastic limit (24 000 lb. per sq. in.), and the pins relatively large, $1\frac{1}{2}$ in. in most cases. The result is, for the short lengths, low values compared to other tests on wrought iron; and for the long lengths, rather high values due to resistance to turning on the pins. As a matter of fact, the group of test results can be represented very closely by a single straight line, which, however, is not of much significance in a consideration of the common type of structural column.

The effect of size of pin on the strength of the column is brought out in these tests by a series in which the pin size varied from $\frac{7}{8}$ in. to $2\frac{1}{4}$ in., and $\frac{l}{r} = 139$ The ultimate strength increased steadily with diameter of pin, from 16 300 to

* *Transactions*, Am. Soc. C. E., Vol. LXXVI (1913), p. 258.
† *Loc. cit.*, Vol. XVIII (1888), p. 103.
‡ *Loc. cit.*, Vol. XI (1882), p. 1, and Report on Tests of Metals, 1881.
§ Report on Tests of Metals and Other Materials, 1883.

22 250 lb. per sq. in., the latter value being about 92% of the elastic limit of the material. This is a good illustration of the effect of pin friction in tending to fix the ends of columns.

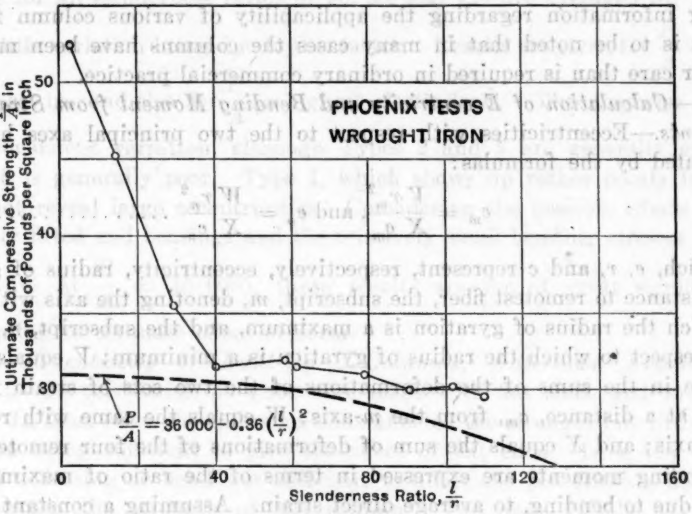


FIG. 14.

*18.—Christie's Test on Wrought Iron and Steel Struts.**—These tests were made on small shapes, generally less than 2 sq. in. in section. The ends were flat, fixed by clamps, hinged and spherical for the wrought iron, and flat only for the steel. In the diagrams of Figs. 7 and 9, only the longer lengths are used, as these are thought to be of some value in reference to failure by deflection. In the case of the longer flat-end tests, it is reported that generally the ends left their bearings at one edge before failure, and in some cases before the maximum load was reached. This action indicated a further deviation from a fixed-end condition than in the case of the tests on larger sections plotted in the diagrams. The flat-end tests, however, have been plotted on Fig. 7, and the fixed and hinged-end tests on Fig. 9. The results are relatively low except in the hinged-end group of Fig. 9.

(C) EFFECT OF VARIOUS DETAILS ON STRENGTH OF COLUMNS

1.—Inherent Eccentricities and Initial Bends

19.—Some information on this subject may be obtained from some of the test data, but many of the older tests give little or none except what may be inferred from the deflections produced by loads. Eccentricity may be due to bends in the column; to eccentrically applied loads; to irregularities of cross-section; or to unequal elasticity of the column components.

Where loads are presumed to be centrally applied, there may be in effect considerable eccentricity, especially in flat-end tests, where unequal bearings would have the effect of eccentric application of loads. Initial bends will also

* *Transactions*, Am. Soc. C. E., Vol. XIII (1884), pp. 253, 285.

result in eccentricity of load with respect to some parts of the column. The best information available from the tests are the strain measurements made at different points along the columns, especially near the center, and considerable data to that effect are given later. These data are of some value in giving information regarding the applicability of various column formulas, but it is to be noted that in many cases the columns have been made with greater care than is required in ordinary commercial practice.

20.—Calculation of Eccentricity and Bending Moment from Strain Measurements.—Eccentricities with respect to the two principal axes have been calculated by the formulas:

$$e_m = \frac{V}{X}\frac{r_m^2}{c_m}, \text{ and } e_n = \frac{W}{X}\frac{r_n^2}{c_n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

in which, e, r, and c represent, respectively, eccentricity, radius of gyration, and distance to remotest fiber, the subscript, m, denoting the axis with respect to which the radius of gyration is a maximum, and the subscript, n, the axis with respect to which the radius of gyration is a minimum; V equals the difference in the sums of the deformations of the two sets of strain measurements at a distance, c_m, from the m-axis; W equals the same with respect to the n-axis; and X equals the sum of deformations of the four remotest fibers.

Bending moments are expressed in terms of the ratio of maximum fiber strain due to bending, to average direct strain. Assuming a constant value of E across the section, this ratio would be equal to the ratio of stresses, and has been so indicated. They have been calculated from the formula:

$$\frac{\text{Bending stress}}{\frac{P}{A}} = \frac{V + W}{X} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

It will be noted that $\frac{V}{X}\frac{P}{A}$ represents bending stress in the direction of maximum moment of inertia, and $\frac{W}{X}\frac{P}{A}$, the bending stress at right angles.

21.—Eccentricities and Bending Stresses in the Am. Soc. C. E. and A. R. E. A. Columns.—Very careful strain measurements were made in these tests, which have been studied from various aspects. An especial effort has been made to determine effect of difference of form in the behavior of the different columns. It is important also to study the effect of slenderness ratio. Fig. 15 gives the values of eccentricities calculated in the manner already described for a value of $\frac{P}{A}$ (average unit stress) of 15 000 lb. per sq. in., and for all the various types of columns. The light lines represent values for the light sections and the heavy lines for the heavy sections. In most cases the values represent the average of three columns. The average of all values is given in the first set of lines.

It will be noted that the value of the eccentricity at 15 000 lb. per sq. in. is not appreciably affected by the slenderness ratio. Few of the eccentricities exceed 0.1 in. Of perhaps more significance are the bending stress ratios, as

these values include not only the effect of eccentricity, but also take account of variation in r and c.

Fig. 16 shows bending stress ratios averaged for each type of column. Values for all slenderness ratios of 50, 85, and 120 are averaged for this purpose, little variation being due to this factor. Results are given for $\frac{P}{A} = 15\,000$ lb. per sq. in., and also for $\frac{P}{A}$ = highest elastic load. The diagrams show no very consistent variation, although Types 2 and 5 are generally good, and Type 8 is generally poor. Type 1, which shows up rather poorly in Fig. 6, does not reveal large eccentricities. Considering the possible effects of inaccurately fitted end bearings and the relatively small bending stresses (average about 5% at $\frac{P}{A} = 15\,000$), these results are not of great significance in attempting to estimate effect of form.

22.—Eccentricity of Built-Up I-Columns, Watertown Arsenal Tests, 1909-14.—In this series, 33 tests were made with flat ends, and 65 with pin ends. In most cases the end conditions affected the strength but little, the pin friction being sufficient to give the effect of flat ends. In a few cases the initial deflection or bend was sufficient to offset the pin friction and greatly to decrease the strength of the column. The data (Table 6) from six columns of the same length $\left(\frac{l}{r} = 175\right)$ and section show how a rather small eccentricity affected the resistance of certain long columns of this series (60 000-lb. steel).

If the ends of the columns shown in Table 6 had been unrestrained, the Euler load which would have produced failure by lateral bending is 9 370 lb. per sq. in. (assuming $E = 29\,000\,000$ lb. per sq. in.).

These data show that an initial bend of small amount caused a marked reduction in the strength of the pin-end columns, but produced little effect on the strength of the flat-end columns. Apparently, the pin friction was sufficient to prevent Column No. 2036, which was reasonably straight, from rotating at the ends when the Euler load for unrestrained ends was applied. With the load nicely centered, it carried more than the flat-end struts of the same length and nearly three times the Euler load. On the other hand, Column No. 2035, with an initial bend of 0.15 in. (about 0.09 r), failed at a load less than one-half as large as that sustained by Column No. 2036, and only 40% larger than the Euler load.

Tests of three columns—Nos. 14911-14913* (sectional area, 9 sq. in.; least $r = 1.05$ in.; $\frac{l}{r} = 186$)—are especially interesting, as strain measurements were made along the entire length of the column. The results of the gauge readings showed that two of the columns had two inflection points, the distance between these points being about 55% of the column length, corresponding closely to truly fixed-end columns. The other showed three inflec-

* Report on Tests of Metals and Other Materials, 1912.

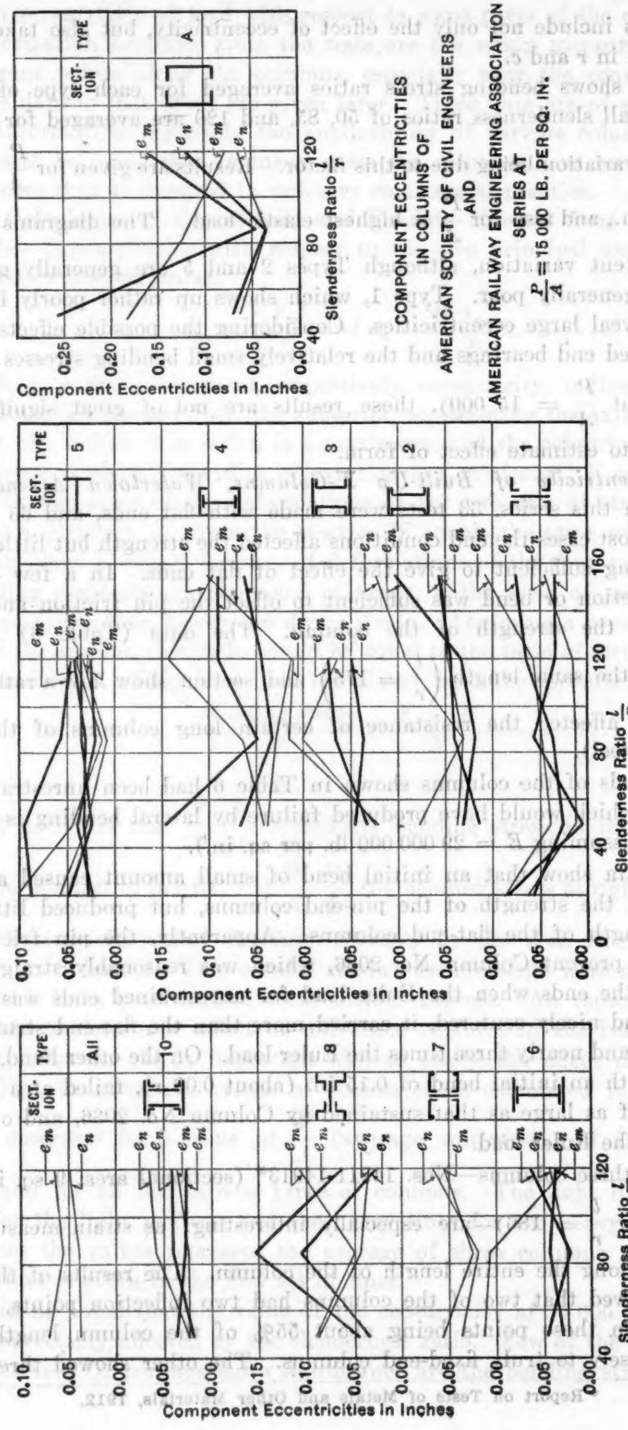

COMPONENT ECCENTRICITIES
IN COLUMNS OF
AMERICAN SOCIETY OF CIVIL ENGINEERS
AND
AMERICAN RAILWAY ENGINEERING ASSOCIATION
SERIES AT
P/A = 15 000 LB. PER SQ. IN.
Component Eccentricities in Inches
Slenderness Ratio L/r
SECTION
TYPE
A
5
4
3
2
1
All
10
8
7
e_m
e_n

FIG. 15.

tion points. These gauge readings also furnished information regarding eccentricity of load throughout the column and the effect of such eccentricity upon the ultimate strength values. Table 7 gives the calculated eccentricities at the ends and center of these columns and observed deflections for loads of 12 000 and 21 000 lb. per sq. in. The values are in inches.

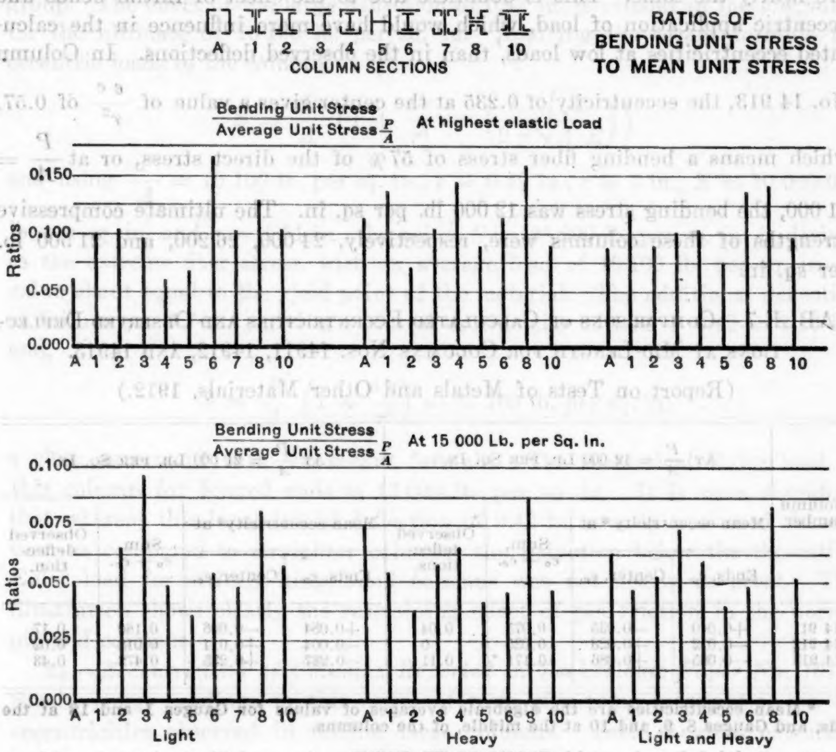


FIG. 16.

TABLE 6.—EFFECT OF INITIAL BEND ON COLUMN STRENGTH.

Column number.	Kind of ends.	Deflection at Center, in Inches. Initial.		Increment in deflection under $\frac{P}{A} = 5\,000$ lb. per sq. in.		Ultimate strength, in pounds per square inch.
		Parallel to pins.	Normal to pins.	Parallel to pins.	Normal to pins.	
2035	Pin	0.14	0.15	0	0.10	18 130
2037	"	0	0.15	0	0.03	23 200
2036	"	0	0	0	0.01	27 010
2032	Flat	None noted		0	0	24 730
2033	"	"	"	0	0.01	26 650
2034	"	0.12	0.10	0	0	26 720

It will be noted from Table 7 that the calculated eccentricities at $\frac{P}{A} = 12\,000$ are considerably greater than the actual deflections, but at $\frac{P}{A} = 21\,000$ they are nearly the same. This is doubtless due to the effect of initial bends and eccentric application of load, which would have more influence in the calculated eccentricities at low loads, than in the observed deflections. In Column No. 14 913, the eccentricity of 0.235 at the center gives a value of $\frac{e\,c}{r^2}$ of 0.57, which means a bending fiber stress of 57% of the direct stress, or at $\frac{P}{A} =$ 21 000, the bending stress was 12 000 lb. per sq. in. The ultimate compressive strengths of these columns were, respectively, 24 000, 26 200, and 21 500 lb. per sq. in.

TABLE 7.—Comparisons of Calculated Eccentricities and Observed Deflections at Mid-Length for Columns Nos. 14911, 14912, and 14913.

(Report on Tests of Metals and Other Materials, 1912.)

Column number.	At $\frac{P}{A}$ = 12 000 Lb. per Sq. In.				At $\frac{P}{A}$ = 21 000 Lb. per Sq. In.			
	Mean eccentricity* at		Sum, $e_o + e_c$.	Observed deflections.	Mean eccentricity* at		Sum, $e_o + e_c$.	Observed deflection.
	Ends, e_o.	Center, e_c.			Ends, e_o.	Center, e_c.		
14 911	+0.040	−0.035	0.075	0.04	+0.084	−0.096	0.180	0.17
14 912	−0.012	+0.023	0.035	0	−0.004	+0.014	0.018	0.02
14 913	−0.085	+0.086	0.171	0.11	−0.237	+0.235	0.472	0.43

* Mean eccentricities are the algebraic averages of values for Gauges 1 and 18 at the ends, and Gauges 8, 9, and 10 at the middle, of the columns.

23.—Initial Bends of **H***-Sections, Watertown Arsenal Tests (1909).*—Many of the pin-end columns had initial bends of considerable amounts, the maximum being 0.42 in., several being from 0.15 to 0.20 in. In tests of columns with $\frac{l}{r}$ = 100 and 150, the maximum loads per square inch and the initial deflection normal to the pins were as given in Table 8.

TABLE 8.—Effect of Initial Bends on H-Columns.

Column number.	$\frac{l}{r}$.	Maximum load, in pounds per square inch.	Initial deflection, in inches.
1986	100	24 000	0.20
1987	100	26 000	0.15
1988	100	27 000	0.08
1980	150	20 360	0.15
1981	150	17 430	0.16
1982	150	10 100	0.42

By reference to Fig. 7, it will be seen that Column No. 1988, with initial deflection of 0.08 in., gave a result not greatly below the flat-end group, but the results from the best of the columns with $\frac{l}{r} = 150$ fell much below that group. The effect of the large deflection of 0.42 in. is evident in the low value for the ultimate of 10 100 lb. per sq. in. Applying the secant formula for eccentric loads to the column,

$$S = \frac{P}{A}\left(1 + \frac{e\,c}{r^2}\sec\left(\frac{l}{2\,r}\sqrt{\frac{P}{A\,E}}\right)\right)$$

and using $\frac{P}{A} = 10\,100$ lb. per sq. in., $e = 0.42$ in., $c = 3$ in., $E = 30\,000\,000$ lb. per sq. in. and $r = 1.54$ in., the value, $S = 38\,200$ lb. per sq. in. is derived as the extreme fiber stress, with an average load of 10 100 lb. per sq. in.—a value about equal to the yield point of the material. The additional deflection at failure was 1.74 in., giving a central eccentricity of $1.74 + 0.42 = 2.16$ in., and,

$$S = \frac{P}{A}\left(1 + \frac{e\,c}{r^2}\right) = 37\,700 \text{ lb. per sq. in.}$$

a close agreement with the secant formula. The theoretical Euler load on this column for hinged ends is 13 000 lb. per sq. in. It is seen, therefore, that whereas this large initial deflection of 0.42 in. greatly weakened the column as compared to straighter columns, the reduction below the theoretical Euler load for strictly hinged-end columns was not nearly as great. This illustration shows clearly the restraining effect of pin friction in the normal pin-end columns.

24.—Eccentricities of Columns Reported in Technologic Paper No. 101.—Strain gauge readings in this series of tests give some information on the eccentricities observed in testing large columns. Table 9 gives calculated values of eccentricity, e, and eccentric ratio, $\frac{e\,c}{r^2}$, for several of these columns, and at an average stress of 30 000 lb. per sq. in. All these columns were of symmetrical cross-section, consisting of built-up I or channel-sections connected by a central web and lacing.

As shown in *Technologic Paper No. 101,* of the Bureau of Standards, the eccentricities in general decreased with increasing load up to 30 000 lb. per sq. in., at least, thus showing that the eccentricities were primarily due to imperfect bearings in the testing machine rather than to bends or inherent eccentricities. The eccentric ratios correspond to the proportionate bending fiber stress, the maximum value of which in Table 9 is 19%, the next highest being 10 per cent. These values range about the same as in the series of tests made by the Society's Special Committee on Steel Columns and Struts.

25.—Other Studies of Eccentricity.—Several studies have been made of the question of eccentricity of loading and that due to bends and irregularities in section, value of E, etc., by many investigators. These studies are con-

cisely summarized by Salmon,* and show a great variety of results, most of them much larger than those found from a study of the latest experimental results determined by strain gauge measurements. The values given are, in general, what may be called inferred eccentricities, determined in some cases by deflection measurements, in others by fitting curves from eccentric-load column formulas to results of tests; and in still others by a detailed consideration of practical conditions in manufacture. The total combined eccentricity due to all causes, expressed as the eccentric ratio, $\frac{e\,c}{r^2}$, ranges from as high as 0.60 to as low as 0.06. Morris† calculated values from deflections in Buchanan's tests of $\frac{e\,c}{r^2}$ from 0.01 to 0.20, averaging 0.07 (perpendicular to

TABLE 9.—Eccentricities of Columns, Technologic Paper No. 101.

Column.	Area, in square inches.	r perpendicular to pin.	$\frac{l}{r}$.	Eccentricity. e, in inches.	Eccentric ratio, $\frac{e\,c}{r^2}$.
H. C.	74.6			0.74	0.19
M. Y.	74.9			0.35	0.09
31 HC.	76.9	6.73	43.5	0.39	0.10
32 S.	76.9			0.40*	0.05*
34 CS.	76.9			0.09	0.02
HC 1.	75.3			0.04	0.01
MY 1	75.3			0.12	0.03
31 HC1.	77.2	7.60	38.5	0	....
32 S1.	77.2			0.42	0.10
34 CS1.	77.2			0.20	0.05

* Parallel to pin. All others perpendicular to pin.

pin) and much larger values parallel thereto. Prichard‡ suggests a value, $\frac{e\,c}{r^2} = 0.1 + \frac{l}{700\,r}$, and Basquin§ suggests a value, $\frac{e\,c}{r^2} = 0.1 + \frac{l}{1000\,r}$, but this is based on existing column formulas, and not on tests. Salmon has plotted values of initial deflections, or bends, of many test columns, and shows that very few have bends greater than $e = \frac{l}{750}$. These suggested values are considerably greater than those calculated from strain gauge measurements given herein. Comparing them to the values for H-columns mentioned in Paragraph 23, Basquin's formula would give for $\frac{l}{r} = 100$, $\frac{e\,c}{r^2} = 0.20$, or $e = 0.16$ in., and for $\frac{l}{r} = 150$, $\frac{e\,c}{r^2} = 0.25$, or $e = 0.20$ in. Salmon's suggestion

* "Columns", by E. H. Salmon, pub. by Frowde and Hudder & Stoughton, London. England.

† *Engineering News*, Vol. 66.

‡ *Transactions*, Am. Soc. C. E., Vol. LXI (1908), p. 174.

§ *Journal*, Western Soc. of Engrs., Vol. 18, p. 543.

for initial bends would give for $\frac{l}{r} = 100$ ($l = 154$ in.), $e = \frac{154}{750} = 0.20$ in., and for $\frac{l}{r} = 150$ ($l = 230$ in.), $e = \frac{230}{750} = 0.30$ in.

26.—Eccentricities Shown by Relation of Ultimate Strength to Yield Point of Relatively Short Columns.—If the average yield point strength of the material is taken as a basis, some information can be deduced as to equivalent eccentricities from the data in Plate I. Taking no account of the effect of deflection on the stress, the maximum reduction of strength is 25% for $\frac{l}{r} = 100$. This would correspond to an increase of fiber stress due to eccentricity of $\frac{25}{100 - 25} = 33\frac{1}{3}\%$, or $\frac{e\,c}{r^2} = 0.33\frac{1}{3}$ per cent. However, at this length, the effect of deflection is considerable. The line, AB (Plate I), represents the result of applying an eccentric load formula in which $\frac{e\,c}{r^2}$ is taken at $0.1 + 0.001 \frac{l}{r}$, and the maximum stress, S, at 36 000 lb. per sq. in. Comparatively few results lie below this line, and none of the tests made by the American Railway Engineering Association or the Society's Special Committee on Steel Columns and Struts. As far as these test results go, such a value, therefore, appears to be conservative, even for built-up members of many elements, and includes necessarily the effect of bends, eccentricity of load, variation in value of E, and all other factors. It represents rather a near approach to a maximum than an average effect.

27.—General Conclusion Regarding Eccentricities.—In the eccentricities calculated by the different methods, the various factors have in effect been lumped together in one result. In the case of flat-end tests, an important element is the adjustment of the specimen in the testing machine, or, as it may be called, eccentricity of loading. This information is an aid in judging the significance of test result, but is of little practical value in estimating eccentricities in the column as used in the structure. Eccentricity of the actual loading, at least for any but pin-ended columns, must be determined by a study of the structure and not from testing machine results.

The other principal causes of eccentricity—crookedness and variation of size and elasticity of the elements—are important, and the tests can be considered as giving some information on this point, if indeed somewhat negative in character. That is, the combined effects of these factors can hardly be greater than the total as shown by the tests, as this would be the result with loads perfectly centered. Referring to Fig. 15, it will be seen that the value of e is seldom more than $\frac{1}{10}$ in., and is little affected by length. Considering this due entirely to initial bends, it would correspond, (considering the column as fixed) to a bend of 0.2 in., a considerably smaller value than that indicated by most estimates. These columns, however, were fabricated with especial care and were doubtless straighter than the average column.

Of all the factors contributing to eccentricity in the column in most modern structures and inherent in the column itself, it would appear that crookedness

is the most important and the only element capable of direct determination. On this subject, information is very scarce, and what is available relates mostly to columns built for testing purposes. It would appear quite possible and feasible to obtain valuable information on this point by numerous careful measurements made in structural shops and on existing structures. This is a line of work well worth consideration. Eccentricity of load on riveted and flat-ended columns is a function of the entire structure, and has little relation to testing machine eccentricity. The column test can give useful information on the effect of crookedness, variation in material, form, and details, and for this purpose, it would appear that the loading should be applied centrally, or with a definite known eccentricity. From such tests, column formulas can be derived suitable for centrally applied loads, or for a certain assumed eccentricity as determined by a study of the action of the column as a part of the structure.

2.—The Unsupported Length of Column Components

28.—Sources of Information.—Although there is no comprehensive series of tests dealing with the effect of the unsupported length of components on the strength of built-up columns, considerable information concerning this subject is obtainable from the tests on wrought-iron columns of the box type reported in Tests of Metals and Other Materials (1881 and 1884), also, from the tests of Bouscaren, Buchanan, the American Railway Engineering Association, Talbot and Moore, and *Technologic Paper No. 101,* U. S. Bureau of Standards. These tests give some information relating to the effect of the unsupported length of cover-plate in channel-plate columns and the unsupported length of channels or ribs; also, some data concerning the effect of unsupported length in segmental columns of the older types.

29.—Unsupported Length of Cover-Plates.—Table 10 has been prepared from tests of wrought-iron columns reported in Tests of Metals and Other Materials (1884). As the pin diameters were $3\frac{1}{2}$ in. and the deflections normal to the pins at maximum loads were small, it was assumed that frictional restraint at the pins was sufficient to prevent rotation. The maximum fiber stresses given in Column (6) of Table 10 were calculated from the deflections recorded in the reports on the assumption of fixed ends. Ratio of rivet pitch to thickness of plate is given in Column (9), and Column (11) shows the behavior of the column at failure, *B* indicating buckling of the cover-plate and *D* indicating general deflection of the column. An examination of this information shows little difference in the behavior of columns of the various plate thicknesses or ratios, $\frac{p}{t}$. In all cases except two, the shortest columns of each group showed plate-buckling at failure, and the longer columns a failure by general deflection. Only one column of $\frac{l}{r}$ exceeding 50 $\left(\frac{l}{r} = 75\right)$ showed a buckled plate at failure. The average maximum fiber stress (Column (6)) for the columns with $\frac{1}{4}$-in. cover-plates was 33 700 lb. per sq. in.; for those with $\frac{5}{16}$-in. plates, it was 35 400 lb. per sq. in., and for those with $\frac{7}{16}$-in. plates,

TABLE 10.—EFFECT OF UNSUPPORTED LENGTH OF COVER-PLATE ON STRENGTH OF COLUMNS OF BOX SECTION CONSISTING OF TWO CHANNELS AND TWO PLATES.

(Report on Tests of Metals and Other Materials, 1884.)

Column number. (1)	Length, in inches. (2)	$\frac{l}{r}$ (least). (3)	End conditions. (4)	Maximum unit load: $\frac{P}{A}$, in pounds per square inch. (5)	Calculated maximum fiber stress, in pounds per square inch. (6)	Rivet pitch, p, in inches. (7)	Thickness of plates, t, in inches. (8)	Ratio: $\frac{p}{t}$. (9)	Ratio: unsupported width to thickness. (10)	Kind of failure. (11)
TWO 6-INCH CHANNELS WITH TWO 10 BY ¼-INCH PLATES.										
377	127.9	46	Flat	31 700	32 600	6	0.26	23	31.8	Buckling
378	127.9	46	"	33 600	34 400	....	0.25	24	32.0	"
367	180	65	Pin	32 300	34 100	....	0.27	22	29.6	Deflection
368	180.1	65	"	33 200	35 800	....	0.28	21	28.6	"
356	240	87	"	29 900	34 900	....	0.26	23	31.8	"*
357	240	87	"	29 200	32 400	....	0.26	23	31.8	"*
TWO 5⅛ BY ¼-INCH WEB-PLATES; FOUR 1⅛ BY 1½-INCH ANGLES; TWO 9⅛ BY ¼-INCH COVER-PLATES.										
371	119.9	49	Pin	31 300	32 400	6	0.22	27	34.1	Buckling
372	120	49	"	31 700	33 500	....	0.26	23	28.8	"
370	180	74	"	31 600	34 400	....	0.22	27	34.1	Deflection*†
369	180	74	"	30 700	32 800	....	0.23	26	32.6	"*†
354	240	98	"	29 000	34 000	....	0.25	24	30.0	"†
355	240	98	"	29 900	33 000	....	0.25	24	30.0	"

* Buckled between rivets after considerable deflection under maximum load.

† Failed by deflecting in plane of the pins.

TABLE 10.—(*Continued.*)

Column number. (1)	Length, in inches. (2)	$\frac{l}{r}$ (least). (3)	End conditions. (4)	Maximum unit load: $\frac{P}{A}$, in pounds per square inch. (5)	Calculated maximum fiber stress, in pounds per square inch. (6)	Rivet pitch, p, in inches. (7)	Thickness of plates, t, in inches. (8)	Ratio: $\frac{p}{t}$. (9)	Ratio: unsupported width to thickness. (10)	Kind of failure. (11)
				Two 8-Inch Channels with Two 12½ by 5/16-Inch Plates.						
379	167.8	47	Flat	35 000	35 300	....	0.26	23	40.4	Buckling
380	167.8	47	"	35 600	37 000	....	0.30	20	35.0	Deflection
358	240	67	Pin	32 100	35 100	....	0.30	20	35.0	"
359	240	67	"	32 300	37 600	....	0.30	20	35.0	"
				Two 7⅜ by 5/16-Inch Web-Plates; Four 2 by 2 by ¼-Inch Angles; Two 12 by 5/16-Inch Cover-Plates.						
346	167.9	50	Flat	32 800	33 000	6	0.32	19	32.8	Buckling
347	167.6	50	"	35 000	35 300	....	0.31	19	33.8	"
342	247.6	75	"	33 000	33 600	....	0.31	19	33.8	Deflection
344	247.8	75	"	34 500	36 200	....	0.33	18	31.8	Buckling
				Two 7 by 7/16-Inch Web-Plates; Four 2 by 2 by ¼-Inch Angles; Two 12 by 7/16-Inch Cover-Plates.						
348	167.8	51	Flat	33 700	34 400	6	0.44	14	23.8	Buckling
349	167.8	51	"	33 100	37 400	....	0.48	12	21.8	Deflection
341	247.6	75	"	33 000	34 800	....	0.48	12	21.8	"
343	247.6	75	"	33 900	34 800	....	0.50	12	21.0	"

it was 35 300 lb. per sq. in. The ratio of the unsupported length to thickness, $\frac{p}{t}$, for the $\frac{1}{4}$-in. plate was about 24, and for the thicker plates about 20 and 12, respectively. The smaller average maximum stress sustained by the $\frac{1}{4}$-in. plates may be taken as some evidence of too great an unsupported length for these plates. This group shows also four values below 33 000, which was the lowest of the other group. Furthermore, four of the columns of the first group of $\frac{l}{r} = 74$ and $\frac{l}{r} = 87$ showed buckling of plates "after considerable deflection under maximum load."

It seems obvious that in the case of columns of small slenderness ratio, such as 40 or, perhaps, 50, a failure of the column at a load approximately equal to or perhaps greater than the average yield point of the material will be accompanied by a buckling of outside plates or outstanding flanges. Such a column is too short to fail by deflection without wrinkling the component parts on the concave side, that is, the material on the concave side will be strained somewhat beyond its yield point at maximum load, and if not held in place will wrinkle or buckle. This over-strain is well illustrated by the fact that columns of $\frac{l}{r}$ less than 30 quite generally carry loads greater than the yield point strength of the material. It would seem, therefore, that buckling of plates in the case of the shortest columns of this series is not to be taken as evidence of too great unsupported length; the most important factor is whether or not the rivet spacing was sufficiently close to develop the full yield point stress in the material before buckling. Judging by the results obtained with the thicker plates, this was probably not accomplished in the case of the thinner plates with $\frac{p}{t} = 24$, but was accomplished with $\frac{p}{t} = 20$, or less. As far as these tests are concerned, they indicate that current practice in this regard is conservative.

Considering the plate between rivets as a flat-ended column, its value of $\frac{l}{r} = 3.46 \times \frac{p}{t}$ and for $\frac{p}{t} = 20$, $\frac{l}{r} = 70$. Reference to the values of column strength given in Plate I indicates that the strength of an ordinary column of such slenderness ratio is likely to be 10 to 15% below the yield point strength of the material; but in effect the unsupported length of the plate is considerably less than the rivet pitch so that the effective slenderness ratio is much less than 70.

Respectfully submitted,

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October 1, 1925.

Progress Report of the Special Committee on Cement*

To the Board of Direction,
American Society of Civil Engineers:

Gentlemen.—On January 15, 1924, your Board authorized the appointment of a Special Committee on Cement and on March 16, 1925, the personnel of this Committee was completed.

The scope of the work of this Committee is indicated by the following extract from the January 15, 1924, report† of the Research Committee:

"It is recommended that a Research Committee on Cement be constituted. The field of the Committee may well include the constitution, nature, and properties of cement, both as a material and as an ingredient in engineering construction, and the means of determining its quality for both general and specific purposes.

"In making this recommendation, the Committee desires to emphasize the need of making a study of the fundamentals relating to cements and their action. Notwithstanding that time has been given to its study, our knowledge of the chemical action of cements is very inadequate, and no great progress is being made. The composition of cements is quite diverse, the chemical action of setting and hardening under different conditions and the nature of the resulting compounds are varied and complex, and the resulting products may differ markedly in strength and durability qualities. It is apparent that a thorough and systematic chemical, physical, and petrographic study of the action of cement should furnish information of the greatest value, knowledge that is essential to a proper consideration of the qualities that may reasonably be expected or required in this construction material and helpful in a consideration of the proper or allowable methods in its use. Such a study would be only one part of the work of a committee. Although Portland cement is the principal material to be considered, other cements would naturally be included in the work. It is expected that the Committee would deal with cement rather than with mortar and concrete, although, of course, the scope should include the action of the cement and its resulting properties for all the various conditions to be found in mortar and concrete and all matters relating to the durability and permanency of construction as affected by the nature and use of the cement. Such conditions as amount of water used, both mixing water and water retained, exposure, expansion and contraction, and changes in moisture content would seem to be involved in the investigation. The chemical reactions and the physical changes under a variety of conditions with cements of diverse composition would need to be studied. Naturally, the Committee should try to learn whether tests of cement specified at present are conclusive and sufficient tests and whether other forms of tests may well supplant any of the present ones. This enumeration is not intended to fix or limit the scope of the Committee's work, but to suggest something of the field. It is not the thought, however, that the Committee would report on proper and improper methods of proportioning, making, and placing concrete, this subject being one that might well be assigned to an engineering practice committee."

Your Committee on Cement now presents its first annual report of progress.

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* Presented to the Annual Meeting, January 20, 1926.

† *Proceedings*, Am. Soc. C. E., March, 1924, Society Affairs, p. 203.

During the year (1925) your Committee has given consideration to many of the broad general questions which are before it and has held a number of meetings at which the various phases of its work have been discussed. Your Committee has also co-operated, by attendance at meetings and by suggestion and conference, with the investigation as to the constitution and properties of Portland cement being carried on at the United States Bureau of Standards under the Portland Cement Fellowship, which was established in 1924 by the Portland Cement Association. This investigation is being most ably conducted under the supervision of Dr. R. H. Bogue, of the Fellowship, and Dr. P. H. Bates, of the Bureau of Standards. This is undoubtedly the most comprehensive investigation of its kind which has ever been undertaken. It is being carried on in a broad scientific manner and gives promise of developing much fundamental data which will be of great value to every manufacturer and consumer of Portland cement. Your Committee understands that it is the intention of the Fellowship to carry on its work over a period of years and to develop these investigations to the utmost. Your Committee desires to record its keen appreciation of the many courtesies extended by those in charge of this important investigation as well as to the Technical Problems Committee of the Portland Cement Association.

Your Committee, in approaching the tasks before it, has been impressed with the fact that the sum total of knowledge respecting cement is surprisingly small. Unlike the metals, the calcareous cements have been investigated only in what may be termed a preliminary way. Present knowledge regarding them is indefinite and unsatisfactory. The problem before your Committee is one of difficulty and complexity. It is not a problem to be solved by direct experimentation and neither will it be possible to reach an understanding except through the development of hypotheses founded on the results of many collateral investigations. The basic elements to be determined may be stated as follows:

(*a*) The chemistry of the processes which occur when cement is tempered with water. That is, how and why does cement set?

(*b*) The conditions which are necessary to bring about the set. In other words, how may the set be controlled so as to produce a maximum of cement quality?

(*c*) The type and form of the compounds in the cement which will produce the best quality of material after set. Which is the equivalent of asking how may cement be improved in its manufacture so as to give a better product after use?

(*d*) The effect on the resulting set of the aggregate and of foreign substances introduced into the aggregate. That is, how does the aggregate affect the set and what is the action of the foreign substances it often contains?

(*e*) The solubility of the cement products. That is, how may a cement be made so as to be less soluble in water and how may the resistance to solubility of any cement be increased?

Two general methods of approaching the problem as a whole present themselves:

(1) The synthetic method, which consists in manufacturing, in as pure a state as possible, the several compounds which are believed to be present in cement and then studying their behavior singly and in combination with each other as well as in the presence of other substances and compounds which may be present in actual use.

(2) The analytical method, which consists in studying the characteristics of cement as it is now manufactured. This method embraces the study of differences in behavior as shown by different cements and it also includes the investigation of the factors and causes which tend to develop differences in the quality of the resulting set.

Both these procedures present their limitations and their difficulties. The investigation now being carried on under the auspices of the Portland Cement Fellowship, as already referred to, is covering the field broadly, while your Committee, for the present, at least, has confined its efforts to the second of the above mentioned methods of approach. Among the various aspects of the problem, your Committee has been and is studying the following phases:

(*a*) The thermal manifestations during the setting process.
(*b*) The extent to which different cements dissolve in the same solvent.
(*c*) The effect of the addition of various salts to the cement and to the mixing water.
(*d*) The sodium and potassium content of different cements.
(*e*) The effect of storing moulded cement specimens in solutions of various salts.
(*f*) The disappearance from solution of the soluble sulphate compounds during the setting process.
(*g*) The variation in the hydrogen-ion concentration during the setting process.
(*h*) The conditions which go to accelerate and to retard set as well as those which tend to produce quality of set.
(*i*) The effect of different quantities of water on the quality of the set.
(*j*) The effect of different curing conditions on the quality and completeness of the set.

In addition to the foregoing, your Committee has under way investigations looking toward a better understanding of the conditions which govern the corrosion and disintegration of concrete.

Your Committee has recognized the growing feeling that the present standard specifications do not, in all cases, sufficiently indicate the characteristics of a cement. In other words, it seems as if these standard tests do not disclose, as to any particular sample, all that is needed to be known regarding it. How much water may be safely used with this cement? Within what temperature ranges may it be placed with the expectation that reasonable results will be secured? What are the maximum possibilities which can be developed by the cement under proper control during its placing and curing? What will be the durability and permanence of a concrete made from this cement? These, among

others, are questions for which the current standard specification holds no answer.

Present practice under the specifications of the day is simply to apply the requirements, and, if they are met, to accept the cement. These requirements include no single criterion as to the concrete-making properties of a cement either with respect to the kind and quality of its hydration products or with respect to the probable permanence and durability of a concrete made from that cement. The quality of a concrete is then judged almost wholly by the compressive strength it shows in moulded specimens at the early age of 28 days and after storage under conditions not comparable with the concrete of which it is supposed to be representative.

It is not the intention of your Committee to voice destructive criticism, but at the beginning of this investigation it is believed to be desirable to outline some of the shortcomings of the art of concrete and cement. Only so will it be possible to view in perspective those points and directions as to which new knowledge is necessary and in which progress and development may be possible of attainment.

Your Committee, in addition to the studies already enumerated, has given consideration to the "specification phase" of the situation and, in so doing, has held in mind the viewpoints of both the consumer and the manufacturer. Present-day cement is, on the whole, a reasonably satisfactory material, but the question may well be asked as to whether it is a material suitable for general use in all situations. Most of the cement now on the market in a general way resembles all the rest but hardly any two samples are exactly alike. Should there not be different kinds of cement, each adapted to a particular field? One kind for highways, one for dams and hydraulic structures, another for exposed outdoor work such as bridge balustrades, while yet another kind would well serve for use in dry interior building construction? No one would consider using mild open-hearth steel for making automobile roller bearings, yet this precisely parallel thing seems to be done every day on concrete constructions everywhere.

Your Committee has therefore given consideration to the test and specification angle of the problem, along the following lines:

(*a*) As to the adequacy and sufficiency of the present standard specifications with particular reference to the quality of the cement products which result after a cement has been tempered with water.

(*b*) As to the several causes of variation in the results of standard tests when made in different laboratories.

(*c*) As to the development of a scheme of test which will more completely disclose the inherent qualities of a cement than do the present tests and which will, at the same time, be less subject to errors of manipulation, of personal equation, and of temperature environment. Such a scheme of test should, moreover, be capable, within seven days, of fully and completely indicating the quality of a cement.

The setting of cement has heretofore generally been considered as a physical phenomenon. The practice has therefore been to determine for each

cement a quantity of water which, when mixed with that cement, will produce a so-called normal consistence or plasticity. In consequence of this procedure, which is the very essence of the present scheme of tests, all cements at the very beginning of their examination are placed on different planes. In other words, under the present standard tests no two cements (unless it so happens that they require the same quantity of water to produce normal consistence) are treated in the same manner because, as is well known, the strength shown by any cement is, to a great extent, dependent on the quantity of water with which it has been tempered. So it is that the concept of a standard consistence operates to penalize one cement and to favor another. The determination of standard consistence moreover requires much skill and is therefore largely dependent on the personal equation of the manipulator. Other non-controlled factors which influence this determination are (1) the temperature and humidity of the laboratory; (2) the degree to which the cement has been burned; (3) the quantity and quality of the gypsum which has been added to the cement; and (4) the extent of the chemical reactions which occur within the cement mass during the period required for the completion of the operations on which the determination is based.

The processes attendant on and occurring during the setting of cement seem to be entirely chemical in their nature, but as more water is added there also occurs a physical separation as between the individual cement particles, and this separation seems to be greater for some cements than for others. If, then, a comparison as between two cements is to be fairly made, it seems that equal weights of the cements should be mixed with equal weights of water. Now if the volume of water used in the test be taken with respect to the cement in the same ratio as that commonly used in average concrete, the result of the test should be more definitely indicative of the cement quality than are the results under the present scheme of tests, which treats each cement on the basis of the arbitrary assumption that the water requirement of every cement is disclosed by its individual "normal consistence."

Concrete containing 5 gal. of water per 94 lb. of cement shows a ratio as between the water and the cement of close to 43 per cent. If, for the purpose of a scheme of tests, this ratio (water weight divided by cement weight) be used and test specimens of neat cement be moulded, it seems that the uncertain factors of personal equation, of temperature, and of humidity are largely eliminated. Such test specimens made of water and neat cement appear to be of great uniformity with respect to both weight and homogeneity.* In Appendix I of this report is a suggested outline of procedure covering the moulding of test specimens along these lines.

In the case of mortar briquettes moulded with standard Ottawa sand the procedure under the present specification begins with the determination of the normal consistence and the mortar batch (3 sand to 1 cement) is then mixed by hand, each briquette being formed by pressing the mortar into the moulds with the thumbs encased in rubber gloves. An attempt has been made to regulate the number of thumb presses and to specify their approximate

* *Engineering News-Record*, October 23, 1924, p. 671.

pressure. The moulds are then turned over and "the operation of heaping, thumbing, and smoothing off repeated." The trowel may be of any size applied with any pressure the operator may care to exert. No plan of manipulation could be less scientific. A rational procedure, capable of producing test specimens of greater uniformity and more nearly indicative of service conditions, is therefore suggested by your Committee and appears in detail in Appendix II of this report.

It seems probable that a tensile test on specimens of neat cement made as suggested in Appendix I discloses the value of that cement as a glue *per se.* That is to say, this test seems to indicate what may be termed the cohesive strength which is developed between the cement particles under conditions which approximate those in a concrete which has been made with 5 gal. of water for each bag of cement.

A tensile test on a mortar of cement and sand seems to disclose a combination of two values: (*a*) the cohesive strength of the cement itself; and (*b*) the adhesive strength developed between the cement and the surfaces of the sand grains. It is not possible, therefore, to ascertain directly from such a test a value for the adhesive strength which the cement develops. This factor of adhesive strength is one of the most important of the qualities of a cement and your Committee has under consideration the devising of a means for its direct determination.

It seems evident that the adhesive strength developed between a particular cement and the surface of any sand or aggregate particle is dependent in large measure on the characteristics of the surfaces of the particles of the aggregate. If, for instance, the surfaces of a sand are coated with oil or paraffin the adhesive strength developed will be very small. The tensile strength of a mortar or a concrete is, in great measure, dependent on the completeness with which the cement can perfect its adhesive bond with the sand and the aggregate. In comparing the tensile strengths of mortars made with different cements it is, in consequence, necessary to know that the surfaces of the sand grains are all alike. In other words, the surfaces of all the sand grains used for a standard mortar test should be standardized before use. The present specifications are silent in this regard and tacitly assume that each lot of "Ottawa" sand, standardized as to size, has the same mortar-making quality as every other lot of that sand. This matter of the character of sand and aggregate surfaces is another of the problems which your Committee has under consideration.

Present practice in the testing of cement requires that the specimens in their moulds shall be stored for 24 hours in a moist closet. At the end of this period they are removed from the moulds and placed in water until the time for test. This procedure seems to be open to two valid criticisms, namely:

(*a*) In the process of setting, all cements, during the first 24 hours, generate heat. Some cements generate much more heat than others. Some give off heat rapidly at an early stage, others at a later stage, while some generate heat slowly over a long period.

Irrespective of the humidity in the "damp closet" the "dampness" which it contains is non-effective with respect to every specimen which is warmer than the air within the closet. With respect to every such specimen the "damp closet" is, in effect, a "dry closet". During the setting period, when a cement is warmer than the atmosphere surrounding it, water is lost by evaporation. In consequence of this loss the solutions within the mass of the cement become more saturated in proportion as water is lost and the rate and order of the hydrations which occur are modified. Hence it appears that two cements of different heat-generating characteristics are subjected to widely differing conditions of exposure while in the damp closet and that, in consequence, the hydration products formed in the setting process are likely to be very different in their nature.

(*b*) Upon removal from the damp closet the specimens are immersed in water. In some laboratories they are stored in tanks through which water constantly circulates. In others they are stored in water which is occasionally changed, while possibly in some the water is never renewed except to make up evaporation losses. If the water in a storage tank is not constantly being changed, it soon becomes charged with the soluble alkalis which leach out of the cement. Since the hydrations of cement seem to proceed more rapidly in proportion as the alkalinity of the storage water is greater, it may be said that specimens stored in solutions containing different alkali concentrations will, at the same age, show different strengths.

Your Committee has under consideration the question of proper storage for cement specimens and hopes to be able to develop a better understanding of the many factors which are involved.

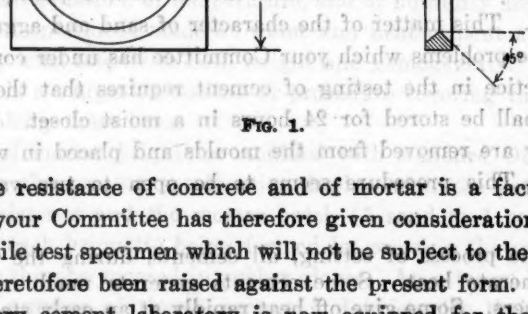

FIG. 1.

The tensile resistance of concrete and of mortar is a factor of great importance and your Committee has therefore given consideration to the development of a tensile test specimen which will not be subject to the valid objections which have heretofore been raised against the present form.

Nearly every cement laboratory is now equipped for the making of the present form of briquettes and with the necessary testing apparatus for

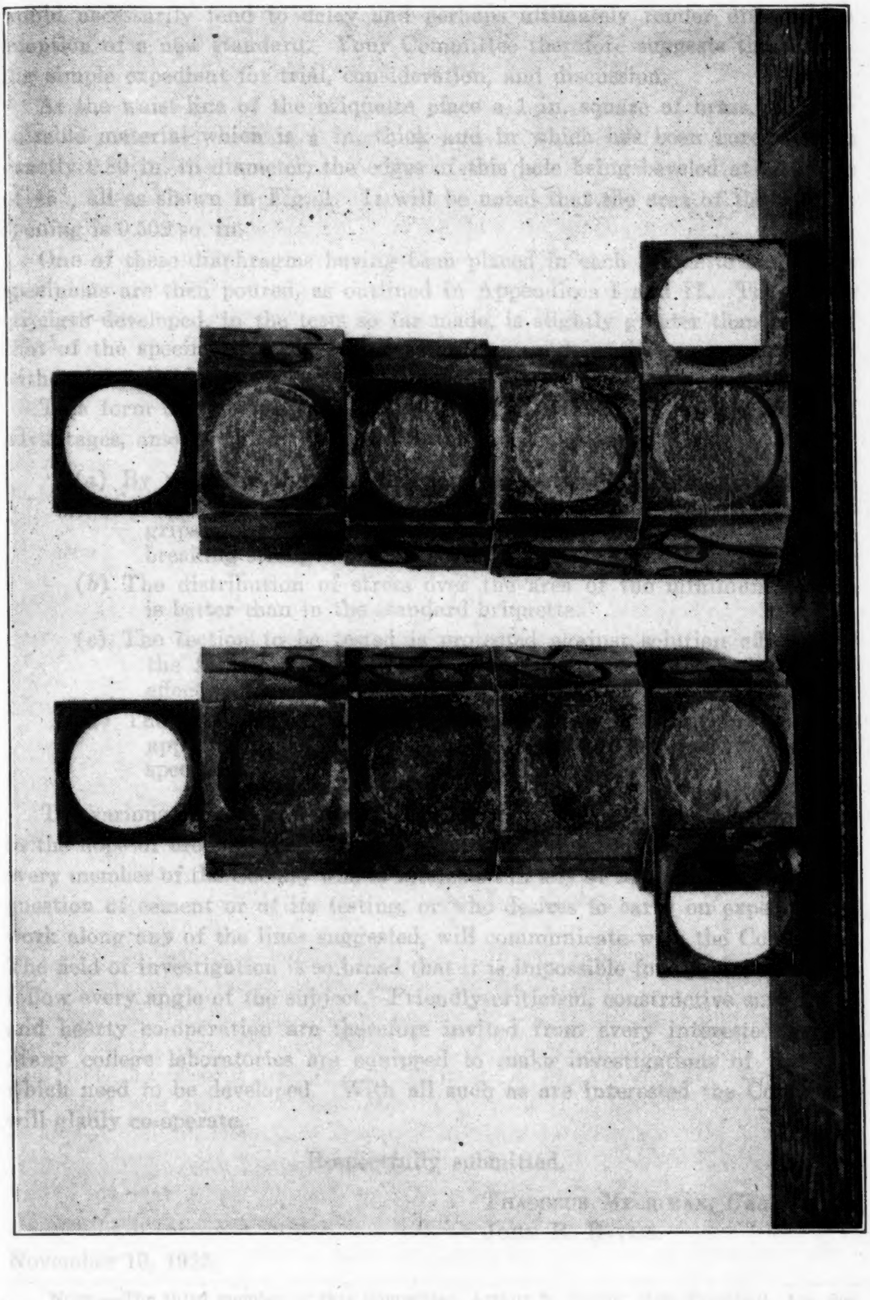

FIG. 2.—TEST SPECIMEN, SHOWING USE OF DIAPHRAGM.

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determining the tensile strength. Any radical change in shape of the test specimen would therefore involve the scrapping of much equipment, which would necessarily tend to delay and perhaps ultimately render difficult the adoption of a new standard. Your Committee therefore suggests the following simple expedient for trial, consideration, and discussion.

At the waist-line of the briquette place a 1 in. square of brass, or other suitable material which is ⅛ in. thick and in which has been bored a hole exactly 0.80 in. in diameter, the edges of this hole being beveled at an angle of 45°, all as shown in Fig. 1. It will be noted that the area of the 0.80-in. opening is 0.502 sq. in.

One of these diaphragms having been placed in each briquette mould the specimens are then poured, as outlined in Appendices I and II. The tensile strength developed, in the tests so far made, is slightly greater than one-half that of the specimens made at the same time and in the same manner but without the diaphragm.

This form of test specimen is illustrated in Fig. 2. It has a number of advantages, among which the following may be enumerated:

(*a*) By reducing the area of the cross-section and, consequently, the total loading, the stresses induced by the pinching effect of the grips are reduced to such values that they do not affect the breaking strength of the specimen at its minimum section.

(*b*) The distribution of stress over the area of the minimum section is better than in the standard briquette.

(*c*) The section to be tested is protected against solution effects and the falling off in strength with time due to the reduction of effective area should be greatly minimized.

(*d*) The effect of improper alignment of the specimen in the grips appears to be less than in the case of the present standard specimen.

The various matters presented in this report are advanced by the Committee in the hope of arousing interest and stimulating discussion. It is hoped that every member of the Society who is interested in any of the many phases of the question of cement or of its testing, or who desires to carry on experimental work along any of the lines suggested, will communicate with the Committee. The field of investigation is so broad that it is impossible for the Committee to follow every angle of the subject. Friendly criticism, constructive suggestion, and hearty co-operation are therefore invited from every interested person. Many college laboratories are equipped to make investigations of the kind which need to be developed. With all such as are interested the Committee will gladly co-operate.

Respectfully submitted,

THADDEUS MERRIMAN, *Chairman,*
JOHN R. BAYLIS.

November 10, 1925.

NOTE.—The third member of this Committee, Arthur N. Talbot, Past-President, Am. Soc. C. E., did not sign the report.

APPENDIX I

Method of Preparing Specimens of Neat Portland Cement Mixed with 43 Per Cent. of Water

To make six tensile briquettes take 600 grammes of the cement and 258 cu. cm. of water. Place the cement in a 2-qt., enameled ware saucepan, add all the water at once and, with a small stick, stir vigorously for 2 min. and for at least 200 rev. Immediately pour into the briquette moulds, filling each one-third full in order from No. 1 to No. 6. Then restir the remainder and fill each mould to the two-thirds point, but in the order No. 6 to No. 1. Again restir and fill each mould in order from No. 1 to No. 6. On this last filling, overfill the moulds to such point that the surface tension of the cement mixture on the oiled surface of the moulds will just prevent the mixture from flowing over the edges.

After standing quietly for 4 hours in the air of the laboratory the surplus cement mixture is carefully scraped from the moulds with a putty knife having a blade 3 in. wide. This scraping process brings no measurable pressure on to the mass of the cement mixture. The moulds are then placed in the moist closet, and at the expiration of 24 hours after the pouring the briquettes are removed and immersed in a tank through which water constantly circulates.

In order to indicate the range of results obtained on several series of tests on briquettes mixed as outlined, the following results (Table 1) are presented.

APPENDIX II

Method of Preparing Mortar Specimens of Portland Cement Two Parts Sand, One Part Cement, and 43 Per Cent. Water

To make six tensile briquettes take 300 grammes of the cement, 600 grammes of standard Ottawa sand, and 129 cu. cm. of water. Thoroughly mix the cement and sand, dry in a 2-qt., enameled saucepan, add all the water at once, and stir vigorously for 2 min. and for at least 200 rev. Then fill the moulds to the same extent and in the same rotation, with intermediate stirring, as described in Appendix I for neat cement specimens. As this sand mix contains the same quantity of water with respect to the cement it will appear to be dryer than the neat cement mix of Appendix I and may, in the moulds, require very slight agitation with the stirring stick to insure removal of air from the mixture. At the end of 4 hours the briquettes are scraped down and at the expiration of 24 hours are stored in water exactly as are those of neat cement.

TABLE 1.

Cement.	Tensile Strength, in Pounds per Square Inch at:											
	1 day.	3 days.	7 days.	14 days.	21 days.	28 days.	3 months.	6 months.	9 months.	1 yr.	1½ yr.	2 yr.
	Portland Cements.											
A 1	113	251	428	465	496	526	495	493	504	478	425	...
A 2	137	260	386	451	476	510	484	364	449	474	445	...
A 3	129	244	379	449	468	460	524	542	516	448	491	...
A 4	135	221	371	431	421	391	426	422	494	437	508	...
A 5	137	277	353	440	408	459	503	...	...	...	...	...
A 6	81	234	344	378	475	477	478	488	519	523	...	...
A 7	140	254	338	385	472	447	494	504	468	472	400	...
A 8	121	262	333	406	440	460	445	470	372	448	...	...
A 9	95	192	316	394	448	439	503	522	498	516	...	...
A10	99	216	289	405	397	440	461	432	...	...	...	...
B 1	142	273	413	456	467	512	...	...	...	...	...	...
B 2	105	196	317	356	427	414	441	441	455	405	...	...
B 3	64	154	264	293	363	411	498	518	492	585	...	...
C 1	114	199	301	394	438	498	516	498	425	494	...	...
C 2	135	195	299	390	434	453	517	583	510	528	515	...
C 3	76	185	283	333	394	461	567	527	534	501	...	...
C 4	80	179	268	334	390	414	517	470	525	554	...	506
C 5	115	171	235	345	393	446	470	478	484	535	477	..
D 1	101	221	295	349	403	384	360	470	367	337	...	...
D 2	87	155	244	261	368	425	466	477	452	478	451	...
D 3	109	200	241	306	341	354	374	450	444	413	413	...
D 4	92	210	239	267	339	399	512	408	412	486	480	...
D 5	72	152	213	297	342	387	465	492	437	475	...	447
E 1	52	184	307	307	366	408	433	445	458	387	...	397
E 2	105	180	273	344	356	377	496	431	496	451	...	398
E 3	97	161	234	314	342	343	384	395	419	363	...	...
F 1	102	182	255	337	374	386	357	377	445	453	...	...
F 2	110	201	248	365	362	409	461	519	535	536	...	...
F 3	61	150	211	270	300	332	455	488	444	462	...	509
G	209	308	408	414	448	511	440	...	...	...	...	...
H	219	244	389	412	455	454	556	...	...	...	...	...
I	125	172	327	425	462	456	562	464	...	...	...	...
J	152	217	322	390	447	386	463	...	...	...	...	...
K	145	244	304	406	483	464	458	410	446	496	...	...
L	107	191	297	374	431	433	548	488	531	547	...	470
M	74	170	248	301	315	339	428	455	478	474	...	...
N	99	178	240	343	377	408	506	498	...	...	...	...
	Non-Staining Cements.											
O	133	231	320	361	422	470	501	469	440	425	...	...
P	104	223	274	407	438	460	537	559	592	...	...	...
Q	62	110	190	243	250	295	421	473	494	522	...	...
R	45	62	94	156	186	238	388	373	...	...	...	...
	Rosendale Cement.											
S	...	...	79	69	84	78	215	314	326	310	...	395

NOTE.—Each value for tensile strength is the average of three breaks. Each letter designates a brand of cement and the number following the letter designates a different sample of the same brand. It will be noted that under each brand or class of cement the results on the several samples have been listed in the order of their strengths at 7 days. These tests were made in the Laboratory of the Board of Water Supply of the City of New York.

TABLE 1.—(*Continued.*)

Cement.	Tensile Strength, in Pounds per Square Inch at:										
	1 day.	3 days.	7 days.	14 days.	21 days.	28 days.	3 months.	6 months.	9 months.	1 yr.	1½ yr.	2 yr.
Special Cements.											
T	331	466	510	547	513	550	461	546	...	...	...	...
U	299	436	419	366	397	408	377	302	269	224	...	...
V	170	419	418	483	441	455	437	431	546	487	...	...
Old Portland Cements.											
W	54	104	150	257	333	323	368	489	528	473	...	...
X	41	62	157	271	315	415	472	461	534	488	...	...

SPECIAL COMMITTEE ON STANDARD CONSTRUCTION CONTRACTS

PROGRESS REPORT INCLUDING STANDARD CONTRACT FOR ENGINEERING CONSTRUCTION

ISSUED BY THE

JOINT CONFERENCE ON STANDARD CONSTRUCTION CONTRACTS IN FEBRUARY, 1925*

COMMITTEE

JACOB S. LANGTHORN, *Chairman* and *Secretary*.

H. ELTINGE BREED, HUNTER MCDONALD,
J. H. BRILLHART, GEORGE H. PEGRAM,
EDWARD H. LEE, HENRY H. QUIMBY.

December 21, 1925.

* Presented to the Annual Meeting, January 20, 1926.

DECEMBER 21, 1925.

TO THE BOARD OF DIRECTION
AMERICAN SOCIETY OF CIVIL ENGINEERS:

Your Special Committee on Standard Construction Contracts transmits herewith its Progress Report containing a Standard Contract for Engineering Construction, issued by the Joint Conference on Standard Construction Contracts, in February, 1925.

We wish to acknowledge valuable assistance from the following gentlemen: Robert S. DuBois, Colorado Section, American Society of Civil Engineers; W. S. Kinnear and Rudolph P. Miller of the New York Section; E. T. Thurston, W. H. Kirkbride and H. S. Vensano of the San Francisco Section; Baxter L. Brown and A. P. Greensfelder of the St. Louis Section; B. K. Klyce, H. C. Hibbs and Thomas H. Robinson of the Engineers Association of Nashville and Edward W. Bush of Hartford, Conn.

It is interesting to note that nine out of the ten delegates to the Joint Conference are members of the Society.

Respectfully submitted,

J. S. LANGTHORN, *Chairman*,
H. ELTINGE BREED,
J. H. BRILLHART,
EDWARD H. LEE,
HUNTER MCDONALD,
GEORGE H. PEGRAM,
HENRY H. QUIMBY.

Progress Report of
Special Committee on Standard Construction Contracts

General Notes

Appended to this report is the form of standard contract, Appendix I.

This form must be supplemented by other forms, such as, the Advertisement, the Instructions to Bidders, the Bond, and the Specifications. The Joint Conference is not considering Specifications and has not made any recommendation as to these other forms. The Joint Conference has endeavored to ascertain from several hundred representative contract forms all those subjects or topics which are common to practically all construction contracts. The various wordings used for each of these subjects were studied and eventually a phrasing was adopted. This document contains all the clauses which are common to-day to practically all construction contracts.

Many of the terms used are subject to change, as "owner" to "city" or "company" and "progress payments" to "estimates." The printed terms are those in most common use, so far as the Joint Conference can ascertain the facts.

The periods of time mentioned in some clauses are averages of present custom in all branches of construction, and have been stated as guides merely. It seems more helpful to state these averages than to leave blanks.

In many instances the dates of beginning and completing work and stipulations for liquidated damages are important. Article 2 of the Agreement should be filled out to cover them. The Joint Conference has discussed the wording of a stipulation for liquidated damages but has reached no decision.

The first record of a Standard Engineering Contract issued in document form, convenient for use in contracts, is that printed in October, 1921, by the Texas Section of the Society.

The Committee on Special Committees of the Society put the need for standard contract forms admirably in its report of June 1921, to the Board.* This report stated in part:

"The agitation now in progress on this subject in Government and contracting circles, makes it highly desirable to have the subject considered from the engineer's standpoint, and the need of reform is acute.

"Most forms of contract have grown through many years by accretion as the results of efforts to meet demonstrated difficulties and weaknesses, producing voluminous forms full of obsolete clauses and hard to interpret, and involving often arbitrary powers on the part of the engineer, susceptible of abuse and, consequently, harassing to the contractor and expensive to the principal.

"A thorough review of the situation and the formulation of general rules, and perhaps standard clauses for specifications, promise an improvement that is well worth attempting.

"We therefore recommend the appointment by the President of a committee of seven, representing generally different branches of engineering and

* *Proceedings*, Am. Soc. C. E., August, 1921, Society Affairs, p. 578.

industry, and different parts of the United States, to consider this subject, and report to the Society."

The purpose of the Joint Conference called December 15, 1921, by Herbert Hoover, Secretary of Commerce, has been stated, as follows:

"Less expenditure for legal services in drawing proper contracts, and the elimination of disputes over contracts already drawn;

"Less duplication of work in the profession attendant on construction;

"Better safeguard for owners and increased public confidence; and

"An improved standard of construction service throughout the country."

ARBITRATION

Provision is made for the arbitration of disputes involving time and money; in all other disputes the contract makes the engineer's decision final. This clause has been the most discussed of any in the document.

The six years' experience of the American Institute of Architects with its present arbitration clause, has shown that by its very presence it prevents disputes from becoming acute. The contractor hesitates before bringing up weak claims before an arbitrator, while the decisions of the architect are tempered for the same reason. There have been remarkably few arbitrations and no lawsuits under that Standard Document.

As far as your Committee can judge from its contact with this question, a considerable majority of engineers are in favor of arbitration.

In this connection the Standard Contract of the Texas Section of the Society contains an arbitration clause, which it is understood has been used satisfactorily by cities in Texas.

In preparing the Arbitration Article the Joint Conference was greatly assisted by the following lawyers who gave freely of their valuable time; Judge Moses H. Grossman, Mr. Joseph Fischer, of House, Grossman and Vorhaus, and Mr. Kenneth Dayton of Cohen, Gutman and Richter. All these gentlemen are experienced in arbitration. Judge Grossman and Mr. Fischer are connected with the Arbitration Society of America and Mr. Dayton with the Arbitration Committee of the New York Chamber of Commerce.

The general question of arbitration is reported on by the Society's Special Committee on Arbitration.*

BUILDING CONSTRUCTION

With regard to Standard Contracts for Buildings the Joint Conference, after a study of both forms with the view of having them identical as far as practicable, has approved a form for buildings. The chief difference between the two forms is in Article 39, "Engineer's (or Architect's) Decision", and in Article 40, "Arbitration". This form for buildings is issued by the American Institute of Architects as the Agreement and General Conditions in the fourth edition of the Standard Documents and may be obtained from almost any dealer in architects' supplies, or from the office of the American Institute of Architects, The Octagon House, Washington, D. C.

* See p. 247.

It is hoped that the publication of this Standard Contract will stimulate written discussion and criticisms which will in due course aid in perfecting revised editions.

Copies of the Standard Contract may be obtained for a nominal sum from dealers or from the Secretary of the Joint Conference, Room 1038, Munsey Building, Washington, D. C.

MEMBERS

OF

JOINT CONFERENCE ON STANDARD CONSTRUCTION CONTRACTS

American Association of State Highway Officials
American Engineering Council
American Institute of Architects
American Railway Engineering Association
American Society of Civil Engineers
American Water Works Association
Associated General Contractors of America
Western Society of Engineers

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STANDARD CONSTRUCTION CONTRACTS

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APPENDIX I

STANDARD CONTRACT

FOR

ENGINEERING CONSTRUCTION

(Not designed for use in Building Construction)

ISSUED BY THE

JOINT CONFERENCE ON STANDARD CONSTRUCTION CONTRACTS

First Edition. February, 1925

FOREWORD

As a result of its first two and a half years of work, the Joint Conference, in 1924, submitted to the various national engineering and contracting associations for consideration a tentative standard contract for engineering construction. Through this document, designed as the third tentative draft, discussion was stimulated and opinion crystallized so that the best practice could be formulated.

Criticism and comments obtained from individuals and associations with respect to the form submitted have necessarily been to some extent hypothetical, as certain principles, incorporated in it, though generally used in building contracts, are not commonly found in engineering practice. The Conference feels that this criticism and comment should be supplemented by conclusions based upon actual test of the principles. With this idea in mind, it has issued the accompanying First Edition of the Engineering Contract, with such modifications as its deliberations during the past year have shown to be advisable.

The First Edition is issued by the Conference as an independent body and has not yet been approved by the member associations. Through actual use of this document, which it is hoped the Engineering Profession will encourage, there will be gained definite knowledge of its serviceability and such defects as it may contain. This experience together with the recommendations of the various national organizations will in due course permit the issuance of revised editions.

STANDARD AGREEMENT

FOR

ENGINEERING CONSTRUCTION

(Not designed for use in Building Construction.)

THIS AGREEMENT made the day of in the year Nineteen Hundred and by and between hereinafter called the Contractor, and hereinafter called the Owner,

WITNESSETH, that the Contractor and the Owner for the considerations hereinafter named agree as follows:

Article 1. Scope of the Work—The Contractor shall furnish all of the materials and perform all of the work shown on the Drawings and described in the Specifications entitled

....

(Here insert the caption descriptive of the work as used on the Drawings and in the other Contract Documents.)

prepared by acting as and in these Contract Documents entitled the Engineer; and shall do everything required by this Agreement, the General Conditions of the Contract, the Specifications and the Drawings.

Article 2. Time of Completion.—The work to be performed under this Contract shall be commenced and shall be completed ....

(Here insert stipulation as to liquidated damages, if any.)

Article 3. The Contract Sum.—The Owner shall pay the Contractor for the performance of the Contract, subject to additions and deductions provided therein, in current funds as follows: ....

(State here the lump sum amount, unit prices, or both, as desired in individual cases.)

Where the quantities originally contemplated are so changed that application of the agreed unit price to the quantity of work performed is shown to create a hardship to the Owner or the Contractor, there shall be an equitable adjustment of the Contract to prevent such hardship.

Article 4. Progress Payments.—The Owner shall make payments on account of the Contract as provided therein, as follows:

On or about the day of each month per cent. of the value, based on the contract prices, of labor and materials incorporated in the work and of materials suitably stored at the site thereof up to the day of that month, as estimated by the Engineer, less the aggregate of previous payments; and upon substantial completion of the entire work, a sum sufficient to increase the total payments to per cent of the contract price.

....

(Insert here any provision made for limiting or reducing the amount retained after the work reaches a certain stage of completion.)

Article 5. Acceptance and Final Payment.—Upon receipt of written notice that the work is ready for final inspection and acceptance, the Engineer shall promptly make such inspection, and when he finds the work acceptable under the Contract and the Contract fully performed he shall promptly issue a final certificate, over his own signature, stating that the work provided for in this

Contract has been completed and is accepted by him under the terms and conditions thereof, and the entire balance found to be due the Contractor, including the retained percentage, shall be paid to the Contractor at the office of the Owner within days after the date of said final certificate. Before issuance of final certificate the Contractor shall submit evidence satisfactory to the Engineer that all payrolls, material bills, and other indebtedness connected with the work have been paid.

The making and acceptance of the final payment shall constitute a waiver of all claims by the Owner, other than those arising from unsettled liens, from faulty work appearing after final payment or from requirement of the Specifications, and of all claims by the Contractor, except those previously made and still unsettled.

If after the work has been substantially completed, full completion thereof is materially delayed through no fault of the Contractor, and the Engineer so certifies, the Owner shall, upon certificate of the Engineer, and without terminating the Contract, make payment of the balance due for that portion of the work fully completed and accepted. Such payment shall be made under the terms and conditions governing final payment, except that it shall not constitute a waiver of claims.

Article 6. The Contract Documents.—The General Conditions of the Contract, the Specifications and the Drawings, together with this Agreement, form the Contract, and they are as fully a part of the Contract as if hereto attached or herein repeated. The following is an enumeration of the Specifications and Drawings:

In witness whereof the parties hereto have executed this Agreement, the day and year first above written.

STANDARD GENERAL CONDITIONS

FOR

ENGINEERING CONSTRUCTION

(Not designed for use in Building Construction)

INDEX TO THE ARTICLES OF THE GENERAL CONDITIONS

Article 1. Definitions.

(*a*) The Contract Documents consist of the Agreement, the General Conditions of the Contract, the Drawings and Specifications, including all modifications thereof incorporated in the documents before their execution. These form the Contract.

(*b*) The Owner, the Contractor and the Engineer are those mentioned as such in the Agreement. They are treated throughout the Contract Documents as if each were of the singular number and masculine gender.

(*c*) Wherever in this Contract the word Engineer is used, it shall be understood as referring to the Engineer of the Owner, acting personally or through an assistant duly authorized in writing for such act by the Engineer.

(*d*) Written notice shall be deemed to have been duly served if delivered in person to the individual or to a member of the firm or to an officer of the corporation for whom it is intended, or if delivered at or sent by registered mail to the last business address known to him who gives the notice.

(*e*) The term subcontractor, as employed herein, includes only those having a direct contract with the Contractor and it includes one who furnishes material worked to a special design according to the plans or specifications of this work, but does not include one who merely furnishes material not so worked.

(*f*) The term "work" of the Contractor or subcontractor includes labor or materials or both, equipment, transportation, or other facilities necessary to complete the Contract.

(*g*) All time limits stated in the Contract Documents are of the essence of the Contract.

Article 2. Execution, Correlation and Intent of Documents.—The Contract Documents shall be signed in duplicate by the Owner and the Contractor. In case the Owner and the Contractor fail to sign the General Conditions, Drawings or Specifications, the Engineer shall identify them.

The Contract Documents are complementary, and what is called for by any one shall be as binding as if called for by all. The intention of the Documents is to include all labor and materials, equipment and transportation necessary for the proper execution of the work. It is not intended, however, that materials or work not covered by or properly inferable from any heading, branch, class or trade of the Specifications shall be supplied unless distinctly so noted on the drawings. Materials or work described in words which so applied have a well-known technical or trade meaning shall be held to refer to such recognized standards.

Article 3. Detail Drawings and Instructions.—The Engineer shall furnish, with reasonable promptness, additional instructions, by means of drawings or otherwise, necessary for the proper execution of the work. All such drawings and instructions shall be consistent with the Contract Documents, true developments thereof, and reasonably inferable therefrom.

Article 4. Copies of Drawings Furnished.—Unless otherwise provided in the Contract Documents, the Engineer will furnish to the Contractor, free of charge, all copies of drawings and specifications reasonably necessary for the execution of the work.

Article 5. Order of Completion.—The Contractor shall submit at such times as may be requested by the Engineer, schedules which shall show the order in which the Contractor proposes to carry on the work with dates at which the Contractor will start the several parts of the work and estimated dates of completion of the several parts.

Article 6. Drawings and Specifications on the Work.—The Contractor shall keep one copy of all drawings and specifications on the work, in good order, available to the Engineer and to his representatives.

Article 7. Ownership of Drawings.—All drawings, specifications and copies thereof furnished by the Engineer are his property. They are not to be used on other work, and with the exception of the signed Contract set, are to be returned to him on request, at the completion of the work. All models are the property of the Owner.

Article 8. Contractor's Understanding.—It is understood and agreed that the Contractor has, by careful examination, satisfied himself as to the nature and location of the work, the conformation of the ground, the character, quality and quantity of the materials to be encountered, the character of equipment and facilities needed preliminary to and during the prosecution of the work, the general and local conditions, and all other matters which can in any way affect the work under this Contract. No verbal agreement or conversation with any officer, agent or employe of the Owner, either before or after the execution of this contract, shall affect or modify any of the terms or obligations herein contained.

Article 9. Materials, Appliances, Employes.—Unless otherwise stipulated, the Contractor shall provide and pay for all materials, labor, water, tools,

equipment, light, power, transportation and other facilities necessary for the execution and completion of the work. Unless otherwise specified, all materials shall be new and both workmanship and materials shall be of a good quality. The Contractor shall, if required, furnish satisfactory evidence as to the kind and quality of materials.

The Contractor shall at all times enforce strict discipline and good order among his employes, and shall not employ on the work any unfit person or any one not skilled in the work assigned to him.

Article 10. Royalties and Patents.—The Contractor shall pay all royalties and license fees. He shall defend all suits or claims for infringement of any patent rights and shall save the Owner harmless from loss on account thereof, except that the Owner shall be responsible for all such loss when a particular process or the product of a particular manufacturer or manufacturers is specified, but if the Contractor has information that the process or article specified is an infringement of a patent he shall be responsible for such loss unless he promptly gives such information to the Engineer.

Article 11. Surveys, Permits and Regulations.—The Owner shall furnish all surveys unless otherwise specified. Permits and licenses of a temporary nature necessary for the prosecution of the work shall be secured and paid for by the Contractor. Permits, licenses and easements for permanent structures or permanent changes in existing facilities shall be secured and paid for by the Owner, unless otherwise specified.

The Contractor shall give all notices and comply with all laws, ordinances, rules and regulations bearing on the conduct of the work as drawn and specified. If the Contractor observes that the drawings and specifications are at variance therewith, he shall promptly notify the Engineer in writing, and any necessary changes shall be adjusted as provided in the Contract for changes in the work. If the Contractor performs any work knowing it to be contrary to such laws, ordinances, rules and regulations, and without such notice to the Engineer, he shall bear all costs arising therefrom.

Article 12. Protection of Work and Property.—The Contractor shall continuously maintain adequate protection of all his work from damage and shall protect the Owner's property from injury or loss arising in connection with this Contract. He shall make good any such damage, injury or loss, except such as may be directly due to errors in the Contract Documents or caused by agents or employes of the Owner. He shall adequately protect adjacent property as provided by law and the Contract Documents. He shall provide and maintain all passageways, guard fences, lights and other facilities for protection required by public authority or local conditions.

In an emergency affecting the safety of life or of the work or of adjoining property, the Contractor, without special instruction or authorization from the Engineer, is hereby permitted to act at his discretion to prevent such threatened loss or injury, and he shall so act, without appeal, if so instructed or authorized. Any compensation, claimed by the Contractor on account of emergency work, shall be determined by agreement or arbitration.

Article 13. Inspection of Work.—The Engineer and his representatives shall at all times have access to the work wherever it is in preparation or progress and the Contractor shall provide proper facilities for such access and for inspection.

If the specifications, the Engineer's instructions, laws, ordinances or any public authority require any work to be specially tested or approved, the Contractor shall give the Engineer timely notice of its readiness for inspection, and if the inspection is by another authority than the Engineer, of the date fixed for such inspection. Inspections by the Engineer shall be promptly made, and where practicable at the source of supply. If any work should be covered up without approval or consent of the Engineer it must, if required by the Engineer, be uncovered for examination at the Contractor's expense.

Re-examination of questioned work may be ordered by the Engineer, and if so ordered the work must be uncovered by the Contractor. If such work be found in accordance with the Contract Documents, the Owner shall pay the cost of re-examination and replacement. If such work be found not in accordance with the Contract Documents, the Contractor shall pay such cost, unless he shall show that the defect in the work was caused by another contractor, and in that event the Owner shall pay such cost.

Article 14. Superintendence: Supervision.—The Contractor shall keep on his work, during its progress, a competent superintendent and any necessary assistants, all satisfactory to the Engineer. The superintendent shall not be changed except with the consent of the Engineer unless the superintendent proves to be unsatisfactory to the Contractor and ceases to be in his employ. The superintendent shall represent the Contractor in his absence and all directions given to him shall be as binding as if given to the Contractor. Important directions shall be confirmed in writing to the Contractor. Other directions shall be so confirmed on written request in each case. The Contractor shall give efficient supervision to the work, using his best skill and attention.

If the Contractor, in the course of the work, finds any discrepancy between the plans and the physical conditions of the locality, or any errors or omissions in plans or in the layout as given by points and instructions, it shall be his duty to immediately inform the Engineer, in writing, and the Engineer shall promptly verify the same. Any work done after such discovery, until authorized, will be done at the Contractor's risk.

Neither party shall employ or hire any employe of the other party without his consent.

Article 15. Changes in the Work.—The Owner, without invalidating the Contract, may order extra work or make changes by altering, adding to or deducting from the work, the Contract Sum being adjusted accordingly. All such work shall be executed under the conditions of the original contract except that any claim for extension of time caused thereby shall be adjusted at the time of ordering such change.

In giving instructions, the Engineer shall have authority to make minor changes in the work not involving extra cost, and not inconsistent with the purposes of the work, but otherwise, except in an emergency endangering life or property, no extra work or change shall be made unless in pursuance of a written order by the Engineer, and no claim for an addition to the Contract Sum shall be valid unless so ordered.

The value of any such extra work or change shall be determined in one or more of the following ways:

(*a*) By estimate and acceptance in a lump sum.
(*b*) By unit prices named in the Contract or subsequently agreed upon.
(*c*) By cost and percentage or by cost and a fixed fee.

If none of the above methods is agreed upon, the Contractor, provided he receives an order as above, shall proceed with the work. In such case and also under Case (*c*) he shall keep and present in such form as the Engineer may direct, a correct account of the net cost of labor and materials, together with vouchers. In any case, the Engineer shall certify to the amount, including reasonable allowance for overhead and profit, due to the Contractor. Pending final determination of value, payments on account of changes shall be made on the Engineer's estimate.

Article 16. Claims for Extra Cost.—If the Contractor claims that any instructions by drawings or otherwise involve extra cost under this Contract, he shall give the Engineer written notice thereof within a reasonable time after the receipt of such instructions, and in any event before proceeding to execute the work, except in emergency endangering life or property, and the procedure

shall then be as provided for changes in the work. No such claim shall be valid unless so made.

Article 17. Deductions for Uncorrected Work.—If the Engineer deems it inexpedient to correct work injured or done not in accordance with the Contract, an equitable deduction from the Contract price shall be made therefor.

Article 18. Delays and Extension of Time.—If the Contractor be delayed at any time in the progress of the work by any act or neglect of the Owner, or of his employes, or by any other contractor employed by the Owner, or by changes ordered in the work, or by strikes, lockouts, fire, unusual delay in transportation, unavoidable casualties or any causes beyond the Contractor's control, or by delay authorized by the Engineer pending arbitration, or by any cause which the Engineer shall decide to justify the delay, then the time of completion shall be extended for such reasonable time as the Engineer may decide.

No such extension shall be made for delay occurring more than seven days before claim therefor is made in writing to the Engineer. In the case of a continuing cause of delay, only one claim is necessary.

If no schedule or agreement stating the dates upon which drawings shall be furnished is made, then no claim for delay shall be allowed on account of failure to furnish drawings until two weeks after demand for such drawings and not then unless such claim be reasonable.

This article does not exclude the recovery of damages for delay by either party under other provisions in the Contract Documents.

Article 19. Correction of Work Before Final Payment.—The Contractor shall promptly remove from the premises all materials condemned by the Engineer as failing to conform to the Contract, whether incorporated in the work or not, and the Contractor shall promptly replace and re-execute his own work in accordance with the Contract and without expense to the Owner and shall bear the expense of making good all work of other contractors destroyed or damaged by such removal or replacement.

If the Contractor does not remove such condemned work and materials within a reasonable time, fixed by written notice, the Owner may remove them and may store the material at the expense of the Contractor. If the Contractor does not pay the expense of such removal within ten days' time thereafter, the Owner may, upon ten days' written notice, sell such materials at auction or at private sale and shall account for the net proceeds thereof, after deducting all the costs and expenses that should have been borne by the Contractor.

Article 20. Suspension of Work.—The Owner may at any time suspend the work, or any part thereof, by giving days' notice to the Contractor in writing. The work shall be resumed by the Contractor within ten (10) days after the date fixed in the written notice from the Owner to the Contractor so to do. The Owner shall reimburse the Contractor for expense incurred by the Contractor in connection with the work under this Contract as a result of such suspension.

But if the work, or any part thereof, shall be stopped by the notice in writing aforesaid, and if the Owner does not give notice in writing to the Contractor to resume work at a date within of the date fixed in the written notice to suspend, then the Contractor may abandon that portion of the work so suspended and he will be entitled to the estimates and payments for all work done on the portions so abandoned, if any.

Article 21. The Owner's Right to Do Work.—If the Contractor should neglect to prosecute the work properly or fail to perform any provision of this contract, the Owner, after three days' written notice to the Contractor, may, without prejudice to any other remedy he may have, make good such deficiencies and may deduct the cost thereof from the payment then or thereafter due the Contractor.

Article 22. The Owner's Right to Terminate Contract.—If the Contractor should be adjudged a bankrupt, or if he should make a general assignment for the benefit of his creditors, or if a receiver should be appointed on account of his insolvency, or if he should persistently or repeatedly refuse or should fail, except in cases for which extension of time is provided, to supply enough properly skilled workmen or proper materials, or if he should fail to make prompt payment to subcontractors or for material or labor, or persistently disregard laws, ordinances or the instructions of the Engineer, or otherwise be guilty of a substantial violation of any provision of the contract, then the Owner, upon the certificate of the Engineer that sufficient cause exists to justify such action, may, without prejudice to any other right or remedy and after giving the Contractor seven days' written notice, terminate the employment of the Contractor and take possession of the premises and of all materials, tools and appliances thereon and finish the work by whatever method he may deem expedient. In such case the Contractor shall not be entitled to receive any further payment until the work is finished. If the unpaid balance of the contract price shall exceed the expense of finishing the work, including compensation for additional managerial and administrative services, such excess shall be paid to the Contractor. If such expense shall exceed such unpaid balance, the Contractor shall pay the difference to the Owner. The expense incurred by the Owner as herein provided, and the damage incurred through the Contractor's default, shall be certified by the Engineer.

Article 23. Contractor's Right to Stop Work or Terminate Contract.—If the work should be stopped under an order of any Court, or other public authority, for a period of three months, through no act or fault of the Contractor or of any one employed by him, or if the Engineer should fail to issue any estimate for payment within seven days after it is due, or if the Owner should fail to pay the Contractor within seven days of its maturity and presentation any sum certified by the Engineer or awarded by arbitrators, then the Contractor may, upon seven days' written notice to the Owner and the Engineer, stop work or terminate this contract and recover from the Owner payment for all work executed and any loss sustained upon any plant or materials and reasonable profit and damages.

Article 24. Removal of Equipment.—In the case of annulment of this contract before completion from any cause whatever, the Contractor, if notified to do so by the Owner, shall promptly remove any part or all of his equipment and supplies from the property of the Owner, failing which the Owner shall have the right to remove such equipment and supplies at the expense of the Contractor.

Article 25. Use of Completed Portions.—The Owner shall have the right to take possession of and use any completed or partially completed portions of the work, notwithstanding the time for completing the entire work or such portions may not have expired; but such taking possession and use shall not be deemed an acceptance of any work not completed in accordance with the Contract Documents. If such prior use increases the cost of or delays the work, the Contractor shall be entitled to such extra compensation, or extension of time, or both, as the Engineer may determine.

Article 26. Payments Withheld.—The Owner may withhold or, on account of subsequently discovered evidence, nullify the whole or a part of any certificate to such extent as may be necessary to protect himself from loss on account of:

(*a*) Defective work not remedied.

(*b*) Claims filed or reasonable evidence indicating probable filing of claims.

(*c*) Failure of the Contractor to make payments properly to subcontractors or for material or labor.

(*d*) A reasonable doubt that the Contract can be completed for the balance then unpaid.

(*e*) Damage to another contractor.

When the above grounds are removed payment shall be made for amounts withheld because of them.

Article 27. Contractor's Liability Insurance.—The Contractor shall maintain such insurance as will protect him from claims under workmen's compensation acts and from any other claims for damages for personal injury, including death, which may arise from operations under this Contract, whether such operations be by himself or by any subcontractor or any one directly or indirectly employed by either of them. Certificates of such insurance shall be filed with the Engineer, if he so require, and shall be subject to his approval for adequacy of protection.

Article 28. Indemnity.—The Contractor shall indemnify and save harmless the Owner from and against all losses and all claims, demands, payments, suits, actions, recoveries and judgments of every nature and description brought or recovered against him, by reason of any act or omission of the said Contractor, his agents or employes, in the execution of the work or in the guarding of it. The Contractor shall, and is hereby authorized to, maintain and pay for such insurance, issued in the name of the Owner, as will protect the Owner from his contingent liability under this contract, and the Owner's right to enforce against the Contractor any provision of this Article shall be contingent upon the full compliance by the Owner with the terms of such insurance policy or policies, a copy of which shall be deposited with the Owner.

The Contractor shall, and is hereby authorized to, maintain and pay for such insurance, issued in the name of the Owner, as will protect the Owner from his contingent liability under this contract, and the Owner's right to enforce against the Contractor any provision of this article shall be contingent upon the full compliance by the Owner with the terms of such insurance policy or policies, a copy of which shall be deposited with the Owner.

Article 29. Fire Insurance.—The Contractor shall secure, in the name of the Owner, policies of fire insurance in amount, form and companies satisfactory to the Engineer, upon such structures and material as shall be specified by the latter, payable to the Owner for the benefit of the Contractor or the Owner as the Engineer shall find their interests to appear.

Article 30. Guaranty Bonds.—The Owner shall have the right, prior to the signing of the Contract, to require the Contractor to furnish bond covering the faithful performance of the Contract and the payment of all obligations arising thereunder, in such form as the Owner may prescribe and with such sureties as he may approve. If such bond is required by instructions given previous to the receipt of bids, the premium shall be paid by the Contractor; if subsequent thereto, it shall be paid by the Owner.

Article 31. Damages.—Any claim for damage arising under this Contract shall be made in writing to the party liable within a reasonable time of the first observance of such damage and not later than the time of final payment, except as expressly stipulated otherwise in the case of faulty work or materials, and shall be adjusted by agreement or arbitration.

Article 32. Liens.—Neither the final payment nor any part of the retained percentage shall become due until the Contractor, if required, shall deliver to the Owner a complete release of all liens arising out of this Contract, or receipts in full in lieu thereof and, if required in either case, an affidavit that so far as he has knowledge or information the releases and receipts include all the labor and material for which a lien could be filed; but the Contractor may, if any subcontractor refuses to furnish a release or receipt in full, furnish a bond satisfactory to the Engineer, to indemnify the Owner against any lien. If any lien remains unsatisfied after all payments are made, the Contractor

shall refund to the Owner all moneys that the latter may be compelled to pay in discharging such a lien, including all costs and a reasonable attorney's fee.

Article 33. Assignment.—Neither party to the Contract shall assign the Contract or sublet it as a whole without the written consent of the other, nor shall the Contractor assign any moneys due or to become due to him hereunder, without the previous written consent of the Engineer.

Article 34. Rights of Various Interests.—Wherever work being done by the Owner's forces or by other contractors is contiguous to work covered by this Contract the respective rights of the various interests involved shall be established by the Engineer, to secure the completion of the various portions of the work in general harmony.

Article 35. Separate Contracts.—The Owner reserves the right to let other contracts in connection with this work. The Contractor shall afford other contractors reasonable opportunity for the introduction and storage of their materials and the execution of their work, and shall properly connect and co-ordinate his work with theirs.

If any part of the Contractor's work depends for proper execution or results upon the work of any other contractor, the Contractor shall inspect and promptly report to the Engineer any defects in such work that render it unsuitable for such proper execution and results. His failure so to inspect and report shall constitute an acceptance of the other contractor's work as fit and proper for the reception of his work, except as to defects which may develop in the other contractor's work after the execution of his work.

To insure the proper execution of his subsequent work the Contractor shall measure work already in place and shall at once report to the Engineer any discrepancy between the executed work and the drawings.

Article 36. Subcontracts.—The Contractor shall, as soon as practicable after the signature of the Contract, notify the Engineer in writing of the names of subcontractors proposed for the work and shall not employ any that the Engineer may within a reasonable time object to as incompetent or unfit.

The Contractor agrees that he is as fully responsible to the Owner for the acts and omissions of his subcontractors and of persons either directly or indirectly employed by them, as he is for the acts and omissions of persons directly employed by him.

Nothing contained in the Contract Documents shall create any contractual relation between any subcontractor and the Owner.

Article 37. Points and Instructions.—The Contractor shall provide reasonable and necessary opportunities and facilities for setting points and making measurements. He shall not proceed until he has made timely demand upon the Engineer for, and has received from him, such points and instructions as may be necessary as the work progresses. The work shall be done in strict conformity with such points and instructions.

The Contractor shall carefully preserve bench marks, reference points and stakes, and in case of wilful or careless destruction, he shall be charged with the resulting expense and shall be responsible for any mistakes that may be caused by their unnecessary loss or disturbance.

Article 38. Engineer's Status.—The Engineer shall have general supervision and direction of the work. He has authority to stop the work whenever such stoppage may be necessary to insure the proper execution of the Contract. He shall also have authority to reject all work and materials which do not conform to the contract, to direct the application of forces to any portion of the work, as in his judgment is required, and to order the force increased or diminished, and to decide questions which arise in the execution of the work.

Article 39. Engineer's Decisions.—The Engineer shall, within a reasonable time after their presentation to him, make decisions in writing on all claims of the Owner or the Contractor and on all other matters relating to

the execution and progress of the work or the interpretation of the Contract Documents.

All such decisions of the Engineer shall be final except in cases where time and/or financial considerations are involved, which, if no agreement in regard thereto is reached, shall be subject to arbitration.

Article 40. Arbitration.—

(*a*).—Demand for Arbitration.—Any decision of the Engineer which is subject to arbitration shall be submitted to arbitration upon the demand of either party to the dispute.

The Contractor shall not cause a delay of the work because of the pendency of arbitration proceedings, except with the written permission of the Engineer, and then only until the arbitrators shall have an opportunity to determine whether or not the work shall continue until they decide the matters in dispute.

The demand for arbitration shall be delivered in writing to the Engineer and the adverse party, either personally or by registered mail to the last known address of each, within ten days of the receipt of the Engineer's decision, and in no case after final payment has been accepted except as otherwise expressly stipulated in the Contract Documents. If the Engineer fails to make a decision within a reasonable time, a demand for arbitration may be made as if his decision had been rendered against the demanding party.

(*b*).—Arbitrators.—No one shall be nominated or act as an arbitrator who is in any way financially interested in this Contract or in the business affairs of the Owner, or the Contractor, or the Engineer, or otherwise connected with any of them. Each arbitrator shall be a person in general familiar with the work or the problem involved in the dispute submitted to arbitration.

Unless otherwise provided by controlling statutes, the parties may agree upon one arbitrator; otherwise there shall be three, one named in writing, by each party to this Contract, to the other party, and the third chosen by those two arbitrators, or if they should fail to select a third within fifteen days, then he shall be appointed by the presiding officer, if a disinterested party, of the Bar Association nearest to the location of the work.* Should the party demanding arbitration fail to name an arbitrator within ten days of his demand, his right to arbitration shall lapse. Should the other party fail to name an arbitrator within said ten days, then said *presiding officer shall appoint such arbitrator within ten days, and upon his failure so to do then such arbitrator shall be appointed on the petition of the party demanding arbitration by a judge of the Federal Court in the district where such arbitration is to be held.

The said *presiding officer shall have the power to declare the position of any arbitrator vacant by reason of refusal or inability to act, sickness, death, resignation, absence or neglect. Any vacancy shall be filled by the party making the original appointment, and unless so filled within five days after the same has been declared, it shall be filled by the said *presiding officer. If testimony has been taken before a vacancy has been filled, the matter must be reheard unless a rehearing is waived in the submission or by the written consent of the parties.

If there be one arbitrator his decision shall be binding; if three, the decision of any two shall be binding in respect to both the matters submitted to and the procedure followed during the arbitration. Such decision shall be a condition precedent to any right of legal action.

(*c*).—Arbitration Procedure.—The arbitrators shall deliver a written notice to each of the parties and to the Engineer, either personally or by registered mail to the last known address of each, of the time and place for the beginning

* To provide some other agency for appointing arbitrators strike out reference to presiding officer of the Bar Association and insert desired designation. In the vicinity of New York, the Arbitration Society of America, Inc., and the Chamber of Commerce of the State of New York have Arbitration Committees which often act in this capacity.

of the hearing of the matters submitted to them. Each party may submit to the arbitrators such evidence and argument as he may desire and the arbitrators may consider pertinent. The arbitrators shall, however, be the judges of all matters of law and fact relating to both the subject matters of and the procedure during arbitration and shall not be bound by technical rules of law or procedure. They may hear evidence in whatever form they desire. The parties may be represented before them by such person as each may select, subject to the disciplinary power of the arbitrators if such representative shall interfere with the orderly or speedy conduct of the proceedings.

Each party and the Engineer shall supply the arbitrators with such papers and information as they may demand, or with any witness whose movements are subject to their respective control, and upon refusal or neglect to comply with such demands the arbitrators may render their decision without the evidence which might have been elicited therefrom, and the absence of such evidence shall afford no ground for challenge of the award by the party refusing or neglecting to comply with such demand.

The submission to arbitration (the statement of the matters in dispute between the parties to be passed upon by the arbitrators) shall be in writing duly acknowledged before a notary. Unless waived in writing by both parties to the arbitration, the arbitrators, before hearing testimony, shall be sworn by an officer authorized by law to administer an oath, faithfully and fairly to hear and examine the matters in controversy and to make a just award according to the best of their understanding.

The arbitrators, if they deem the case demands it, are authorized to award to the party whose contention is sustained such sums as they shall consider proper for the time, expense and trouble incident to the arbitration, and if the arbitration was demanded without reasonable cause, damages for delay and other losses. The arbitrators shall fix their own compensation, unless otherwise provided by agreement, and shall assess the costs and charges of the arbitration upon either or both parties.

The award of the arbitrators shall be in writing and acknowledged like a deed to be recorded, and a duplicate shall be delivered personally or by registered mail, forthwith upon its rendition, to each of the parties to the controversy and to the Engineer. Judgment may be rendered upon the award by the Federal Court or the highest State Court having jurisdiction to render same.

The award of the arbitrators shall not be open to objection on account of the form of the proceedings or the award, unless otherwise provided by the controlling statutes. In the event of such statutes providing on any matter covered by this Article otherwise than as hereinbefore specified, the method of procedure throughout and the legal effect of the award shall be wholly in accord with said statutes, it being the intention hereby to lay down a principle of action to be followed, leaving its local application to be adapted to the legal requirements of the jurisdiction having authority over the arbitration.

The Engineer shall not be deemed a party to the dispute. He is given the right to appear before the arbitrators to explain the basis of his decision and give such evidence as they may require.

Article 41. Lands for Work.—The Owner shall provide the lands upon which the work under this Contract is to be done, except that the Contractor shall provide land required for the erection of temporary construction facilities and storage of his material, together with right of access to same.

Article 42. Cleaning Up.—The Contractor shall, as directed by the Engineer, remove from the Owner's property and from all public and private property, at his own expense, all temporary structures, rubbish and waste materials resulting from his operations.

Progress Report of Special Committee on Irrigation Hydraulics*

TO THE BOARD OF DIRECTION,

AMERICAN SOCIETY OF CIVIL ENGINEERS:

GENTLEMEN.—As stated in previous reports† this Committee has selected ten subjects for investigation. Each subject has been assigned to a sub-committee. In some cases engineers not on this Committee, but having special knowledge of certain subjects or facilities for research have been added as *ex officio* members of these Sub-Committees.

The subjects under investigation and the Sub-Committee assignment of each follow:

I.—Evaporation Losses from Reservoirs. Sub-Committee: F. C. Scobey, R. L. Parshall, and A. L. Sonderegger.

I(*A*).—Evaporation from Soils. Sub-Committee: Franklin Thomas, A. L. Sonderegger, and R. L. Parshall.

II.—Losses in Canal Conversions. Sub-Committee: J. L. Savage, J. C. Stevens, F. C. Scobey, and R. A. Monroe.

III.—Water Movement and Pressure Under Dams. Sub-Committee: J. L. Savage, R. A. Monroe, and B. A. Etcheverry; *ex officio* members: E. L. Chandler, M. Am. Soc. C. E., M. J. Orbeck, M. Am. Soc. C. E., and R. D. Hubbard, Engineer, U. S. Bureau of Reclamation, Denver, Colo.

IV.—Losses in Siphon Spillways. Sub-Committee: F. C. Scobey, Franklin Thomas, and A. L. Sonderegger.

V.—The Silt Problem. Sub-Committee: Franklin Thomas and B. A. Etcheverry.

VI.—Chutes and Drops. Sub-Committee: Julian Hinds; *ex-officio* member: A. T. Mitchelson, Irrigation Engineer, U. S. Department of Agriculture, Berkeley, Calif.

VII.—Scouring Below Dams. Sub-Committee: R. A. Monroe and B. A. Etcheverry; *ex officio* members: I. C. Steele, M. Am. Soc. C. E., P. O. Crawford, M. Am. Soc. C. E., W. H. Nalder, Assoc. M. Am. Soc. C. E., and H. E. Gruner, M. Am. Soc. C. E.

VIII.—Measuring Irrigation Deliveries. Sub-Committee: R. L. Parshall, J. C. Stevens, and Julian Hinds.

IX.—The Design of Side Channel Spillways. Sub-Committee: J. L. Savage, Julian Hinds, R. A. Monroe, and B. A. Etcheverry.

It is the plan of the Committee to stimulate research in these subjects by public and private organizations and to secure papers on them for publication by the Society from those especially qualified to treat of them, in order to bring out discussion and additional data. Each subject will then be disposed of by a report of the Committee summarizing the existing knowledge of the subject at the time of its publication.

One such subject has already been disposed of, namely, "Permissible Canal Velocities", and the final report of the Committee by Samuel Fortier and F. C. Scobey, Members, Am. Soc. C. E., has been published‡ by the Society.

* Presented to the Annual Meeting, January 20, 1926.

† *Proceedings*, Am. Soc. C. E., March, 1924, Society Affairs, p. 288, and March, 1925, Society Affairs, p. 137.

‡ *Proceedings*, Am. Soc. C. E., September, 1925, Papers and Discussions, p. 1397.

STATUS OF INVESTIGATIONS BY SUBJECTS

The status of the Committee's work with reference to each of the subjects mentioned follows:

I.—Evaporation Losses from Reservoirs.—A paper by Ivan E. Houk, M. Am. Soc. C. E., entitled "Evaporation on United States Reclamation Projects", was secured by the Committee and has been accepted for publication by the Society.* This paper summarizes the data in the files of the United States Bureau of Reclamation, that otherwise would not have been available for reference.

The Committee has been endeavoring to secure actual evaporation losses from large water surfaces, and simultaneous comparison of losses as indicated by floating pans and land pans of various types. Efforts were made to secure such data during the past season (1925) at the East Park Reservoir on the Orland Project of the U. S. Bureau of Reclamation. Unusual floods, however, prevented the securing of the desired results. An attempt will be made again next season (1926). It is also planned to utilize one of the reservoirs in Southern California for this purpose.

The only data of value giving coefficients for various types and sizes of pans now available are those secured by R. B. Sleight, Assoc. M. Am. Soc. C. E., at the Denver Laboratories† wherein comparisons were made with pans up to 12 ft. in diameter. The Committee wishes to extend this work to include large lake surfaces in order that the great mass of pan-evaporation records may be intelligently interpreted.

I(A).—Evaporation from Soils.—This subject was added to the Committee's list at the meeting of July 6, 1925. The U. S. Department of Agriculture is conducting laboratory experiments at Fort Collins, Colo., on evaporation from moist soils. This work is under the immediate direction of R. L. Parshall, Affiliate, Am. Soc. C. E.

The evaporation and percolation of rainfall are closely related and are important elements in water-supply studies of topographically closed basins in the arid regions. How much rainfall and what rates of intensity are required before any of it can reach the water-table? The Committee hopes to secure some data on this phase of the subject by certain tank experiments contemplated at the Laboratories of the California Institute of Technology, at Pasadena, under the direction of Franklin Thomas and A. L. Sonderegger, Members, Am. Soc. C. E.

II.—Losses in Canal Conversions.—Certain experiments were made in 1924 by Julian Hinds, M. Am. Soc. C. E., on existing structures of the United States Reclamation Bureau. Laboratory experiments are being undertaken at Berkeley, Calif., continuing the work done in 1924, particularly on structures wherein velocities are being diminished. Funds are also expected from the U. S. Bureau of Reclamation and the U. S. Department of Agriculture for continued tests on existing structures.

* *Proceedings*, Am. Soc. C. E., January, 1926, p. 4.

† *Journal of Agricultural Research*, Vol. X, No. 5, July 30, 1917.

It appears from data so far secured that in building conversion structures in the future those wherein velocities are diminished will require more careful design than those wherein velocities are increased. In the latter any simple rounded entrance that avoids cavitation will increase the velocities without appreciable loss, but where velocities are diminished a substantial portion of the velocity head cannot be recovered except at considerable pains and expense.

Experiments are contemplated on conversion sections of some of the conduits of the Pacific Gas and Electric Company wherein flows as great as 3 000 sec-ft. are involved.

III.—Water Movement and Pressure Under Dams.—The Committee has in prospect a paper by E. L. Chandler, M. Am. Soc. C. E., on the results of tests on a dam at Maquoketa, Iowa.

A compilation of data in the files of the U. S. Bureau of Reclamation is being made by R. D. Hubbard, Engineer at the Denver Office.

Pressure pipes are being placed in the American Falls Dam, in Idaho, by the U. S. Bureau of Reclamation. On the Pit River No. 3 Dam of the Pacific Gas and Electric Company, pipes were placed and pressure records will be secured.

Mention is also made of the work being done by A. L. Fellows, Senior Irrigation Engineer of the Denver Office, for the U. S. Department of Agriculture.*

IV.—Losses in Siphon Spillways.—Laboratory tests are being undertaken under the direction of Professor Franklin Thomas at the California Institute of Technology, at Pasadena. Field tests are also being arranged for on the canal of the U. S. Bureau of Reclamation at Yuma, Ariz., where the flow can be artificially controlled, and also on the Emigrant Creek Dam near Ashland, Ore.

Data in the files of the U. S. Bureau of Reclamation are being compiled by W. H. Nalder, Assoc. M. Am. Soc. C. E.

V.—Silt Problems.—It has been claimed by some engineers in India that silt in the water has the effect of lowering the value of n in the Kutter formula, that is, with the same hydraulic elements a greater quantity of silty water will be discharged than of clear water. Any confirmation or refutation of this claim is desired by the Committee.

Data in the files of the U. S. Bureau of Reclamation are being compiled by Ivan E. Houk, M. Am. Soc. C. E.

The report of the Committee for 1924† contains a paper on this subject, but it is not the Committee's final report. Additional data must be secured before such a report can be prepared.

VI.—Chutes and Drops.—Arrangements are being made for an extensive series of field tests on existing structures by engineers of the U. S. Bureau of Reclamation and the U. S. Department of Agriculture. It is expected that a small allotment for such work will be included in the budgets of these organiza-

* See Progress Report of this Committee, *Proceedings*, Am. Soc. C. E., March, 1925, Society Affairs, p. 139.

† *Proceedings*, Am. Soc. C. E., March, 1925, Society Affairs, p. 141.

tions for the next fiscal year. Some tests have already been made, but the results are withheld until additional data are in hand.

VII.—Scouring Below Dams.—It is expected that the results of tests on models of dams constructed by the Pacific Gas and Electric Company and also by the California-Oregon Power Company will be available for presentation, together with the behavior of the dams themselves under flood flow. These data will cover the construction of aprons with piers and baffles to prevent scouring of foundation materials.

Data in the files of the U. S. Bureau of Reclamation are being compiled by H. R. McBirney, Engineer of the Denver Office.

VIII.—Measuring Irrigation Deliveries.—The Committee realizes the necessity of some practicable measuring device for open channels of all sizes where the head lost by reason of such measurements is a minimum, a device that will indicate the flow with reasonable accuracy, independent of the variable conditions caused by silt, weeds, and back-water.

A paper on the "Improved Venturi Flume" by R. L. Parshall, Affiliate Am. Soc. C. E., presented through this Committee, has been published* by the Society, and is now open for discussion. Some experiments have been made on a simplification of this device and other experiments on additional modifications are being arranged for the coming year.

IX.—The Design of Side Channel Spillways.—A very complete analysis of the hydraulics involved in the design of such spillways, methods of applying these principles, and a summary of experiments on models and existing spillways are included in a paper entitled, "Side Channel Spillways: Hydraulic Theory, Economic Factors and Experimental Determination of Losses" by Julian Hinds, M. Am. Soc. C. E., presented to the Society through this Committee. It has been published† and is now open for discussion.

In order to test the fundamental theory of the Hinds' analysis, namely, that water overflowing the spillway crest has no kinetic energy in the direction of continued motion, experiments on the impact losses in pipes intersecting at right angles are now being conducted at the Hydraulic Laboratory of the University of California, at Berkeley.

Field tests of such spillways are contemplated on the one recently completed at the Rimrock Dam, on Tieton River, Yakima Project, U. S. Bureau of Reclamation, and on another now under construction by the Pacific Gas and Electric Company, California, at Lake Fordyce, California.

Committee Affairs

The Special Committee on Irrigation Hydraulics was appointed on June 30, 1922. General meetings of the Committee have been held as follows: October 4 and 5, 1922, at San Francisco, Calif.; September 25 and 26, 1923, at San Francisco, Calif.; September 5 and 6, 1924, at Portland, Ore.; July 6 and 7, 1925, at Salt Lake City, Utah; and November 6 and 7, 1925, at San Francisco and Berkeley, Calif.

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* *Proceedings*, Am. Soc. C. E., September, 1925, Papers and Discussions, p. 1340.

† *Loc. cit.*, p. 1350.

At the meeting in Salt Lake City, on July 6, 1925, the entire Committee tendered its resignation to the Board of Direction in order to give the Board of free hand in making a change in personnel if it so desired.

The members of the present Committee take this occasion to publicly thank the former members who found it necessary, for business reasons, or for changes in their lines of activities, to retire from active participation in the work of the Committee, for their splendid help and co-operation during the past three years.

The Committee also wishes to acknowledge with sincere appreciation the fine spirit of co-operation that has manifested itself among the officers of the U. S. Bureau of Reclamation, the Division of Agricultural Engineering of the U. S. Department of Agriculture, and other Government and private agencies. Without such co-operation the work of this Committee would be greatly handicapped.

Respectfully submitted,

D. C. Henny, *Chairman*,
J. C. Stevens, *Secretary*,
B. A. Etcheverry,
J. L. Savage,
Fred C. Scobey,
Franklin Thomas,
R. L. Parshall,
Julian Hinds,
A. L. Sonderegger,
R. A. Monroe.

Portland, Ore., December 1, 1925.

Progress Report of Special Committee on Arbitration*

To the Board of Direction,

American Society of Civil Engineers:

Gentlemen.—Your Special Committee on Arbitration, appointed under resolution of your Board dated January 19, 1925, begs leave to report as follows:

The function of your Committee was to study the arbitration laws passed recently by Congress and by several of the States, to report as to their bearing upon the interests of members of the Society, and to recommend what action, if any, the Society, its Local Sections, and members should take with reference to these laws or the movement to secure similar legislation in other States.

Purpose and Effect of the New Arbitration Laws.—Your Committee believes that the members of the Society, generally, favor the settlement by arbitration of disputes regarding contractual obligations. In fact, arbitration clauses have been commonly used in engineering contracts for more than a generation.

However, an agreement to arbitrate has not, heretofore, been irrevocable. Either party could, despite his agreement, refuse to submit a difference to arbitration, or, having proceeded with arbitration, could refuse to accept the decision. It is this defect that the new laws are designed to eliminate. Under these laws, already on the statute books of the United States and of the States of New York, New Jersey, Oregon, and Massachusetts, an agreement to arbitrate an existing dispute, or a clause in a contract to arbitrate any dispute that may arise thereunder, is valid, enforceable, and irrevocable, and the arbitrator's award, upon motion of either party becomes a judgment of the Court. If a party to such an agreement or such a contract in the States mentioned and in cases normally falling under the jurisdiction of the Federal Courts, should refuse to proceed with arbitration, the appropriate Court will appoint the arbitrator, and the arbitration must then go forward. The agreement to arbitrate either an existing dispute or disputes that may arise under a contract is a voluntary act of the parties at interest. Once, however, the agreement has been entered into, it is valid, enforceable, and irrevocable.

It is evident, therefore, that teeth have been put into arbitration laws in those jurisdictions having the new statutes. In those States, and in cases normally falling under the Federal Courts, an arbitration clause can no longer be flouted, nor the decision of the arbitrator disregarded. (The Federal Courts have jurisdiction over cases arising out of maritime transactions and over such controversies regarding matters of interstate commerce as exceed $3 000 in value.)

Action Recommended to the Society.—Obviously, having long advocated and applied the principle of arbitration for the settlement of disputes, engi-

* Presented to the Annual Meeting, January 20, 1926.

neers will welcome the new laws, take advantage of them in the States where they have been passed, and join in advocating the passage of similar laws in States where they do not now exist.

Your Committee further believes that the Society (1) should assist in making known the existence of these new and effective arbitration laws in the States where they now exist; and (2) should urge its Local Sections in other States to study these laws and join with commercial and civic bodies in endeavoring to secure the passage of similar acts in their own States.

Your Committee therefore recommends as follows:

1.—That this report, together with Appendices I, II, and III, attached hereto, be published for the information of the members of the Society, to the end that the existence of these new laws, State and Federal, may become thoroughly known among the Society's membership.

(Appendix I contains the New Jersey law in full, said law being typical of the new legislation in question; Appendix II, a typical arbitration clause for insertion in contracts; Appendix III, the rules of the Arbitration Society of America.)

2.—That the Local Sections in States where such laws do not exist be urged to study the subject to the end that they may join with commercial and civic organizations in securing the passage of such laws.

3.—That the Committee on Arbitration be authorized to communicate with the Local Sections for the purpose of arousing their interest in the matter, as set forth.

4.—That the Secretary be directed to prepare 1 000 reprints of the report and its attached Appendices at the expense of the Society, for the use of the Committee in its work with the Sections.

Respectfully submitted,

J. F. Coleman,
A. H. Markwart,
S. M. Swaab,
L. C. Wason,
E. J. Mehren, *Chairman*.

October 20, 1925.

APPENDIX I

THE NEW JERSEY ARBITRATION ACT*

Chapter 134, Laws of 1923

(In effect July 4, 1923)

An Act concerning arbitration and awards.

BE IT ENACTED by the Senate and General Assembly of the State of New Jersey.

Arbitration Provision Valid

1.—A provision in a written contract to settle by arbitration a controversy thereafter arising out of the contract or the refusal to perform the whole or

* This law is typical of the new statutes passed and approved in New York, Oregon, and Massachusetts, and by Congress.

any part thereof or an agreement in writing to submit an existing controversy to arbitration pursuant to section two hereof, shall be valid, enforceable and irrevocable, save upon such grounds as exist at law or in equity for the revocation of any contract.

Agreement for Arbitration

2.—Two or more persons may submit in writing to arbitration any controversy existing between them at the time of the agreement to submit, which arises out of a contract or the refusal to perform the whole or any part thereof or the violation of any other obligation. They may also so agree that a judgment of a court of record, specified in writing, shall be rendered upon the award, made pursuant to the submission. If the court is thus specified they may also specify the county in which the judgment shall be entered. If the writing does not specify, the judgment may be entered in any county.

Practice in Non-Performance of Agreement

3.—A party aggrieved by the failure, neglect or refusal of another to perform under an agreement in writing providing for arbitration may petition any justice of the Supreme Court or judge of a Circuit Court, holding court for the county where either party resides, for an order directing that such arbitration proceed in the manner provided for in such agreement. Five days' notice in writing of such application shall be served personally upon the party in default. The justice or judge shall hear the parties, and upon being satisfied that the making of the agreement or such failure to comply therewith is not in issue, shall make an order directing the parties to proceed to arbitration in accordance with the terms of the agreement. If the making of the agreement or the default be in issue an order shall be made directing a summary trial thereof. Where such an issue is raised, the party alleged to be in default may, on or before the return day of the notice of application, demand a jury trial of such issue, and if such demand be made, said justice or judge shall make an order referring the issue or issues to a jury called and impanelled in the manner provided for the trial of actions at law. If no jury trial be demanded said justice or judge shall hear and determine such issue. If the finding be that no agreement in writing providing for arbitration was made, or that there is no default in proceeding thereunder, the proceeding shall be dismissed. If the finding be that a written provision for arbitration was made and there is a default in proceeding thereunder, an order shall be made summarily directing the parties to proceed with the arbitration in accordance with the terms thereof.

Agreement for Naming Arbitrators; Vacancy

4.—If, in the agreement, provision is made for a method of naming or appointing an arbitrator or arbitrators or an umpire, such method shall be followed, but if no method be provided therein, or if a method be provided and any party thereto shall fail to avail himself of such method, or for any other reason there shall be a lapse in the naming of an arbitrator or arbitrators or umpire, or in filling a vacancy, then, upon application by either party to the controversy, any justice or judge as aforesaid shall designate and appoint, an arbitrator or arbitrators, or umpire, as the case may require, who shall act under the said agreement with the same force and effect as if he or they had been specifically named therein; and unless otherwise provided, the arbitration shall be by a single arbitrator.

Judge May Stay Action

5.—If any suit or proceeding be brought upon any issue arising out of an agreement providing for the arbitration thereof, any justice or judge as

aforesaid, upon being satisfied that the issue involved in such suit or proceeding is referable to arbitration, shall stay the action until an arbitration has been had in accordance with the terms of the agreement; provided, that the applicant for the stay is not in default in proceeding with such arbitration.

Summary Hearing

6.—Any application made under the authority of this Act shall be heard in a summary way in the manner provided by law for the making and hearing of motions, except as otherwise herein expressly provided.

Hearing with Less Number, Etc.; Witnesses

7.—When more than one arbitrator is agreed to all the arbitrators shall sit at the hearing of the case, unless, by consent in writing, all parties shall agree to proceed with the hearing with a less number. The arbitrator or arbitrators so sitting may require any person to attend before him or them as a witness and in a proper case to bring with him any book or written instrument. The fees for such attendance shall be the same as the fees of witnesses before masters. Summons shall issue in the name of the arbitrator or arbitrators, or a majority of them, and shall be signed by the arbitrator or arbitrators, or a majority of them, and shall be directed to the said person and shall be served in the same manner as subpœnas to testify before a court of record of this State; if any person or persons so summoned to testify shall refuse or neglect to obey said summons upon petition any justice or judge as aforesaid may compel the attendance of such person or persons before said arbitrator or arbitrators, or punish said person or persons for contempt in the same manner now provided for the attendance of witnesses or the punishment of them in the courts of this State.

Notice of Motion to Confirm Award

8.—At any time within three months after the award is made, unless the parties shall extend said time in writing, which award must be in writing and acknowledged or proved in like manner as a deed for the conveyance of real estate, and delivered to one of the parties or his attorney, any party to the arbitration may apply to any justice or judge aforesaid, for an order confirming the award; and thereupon said justice or judge must grant such an order, unless the award is vacated, modified or corrected, as prescribed in the next two sections. Notice in writing of the motion must be served upon the adverse party or his attorney five days before the hearing thereof.

When Award May Be Vacated

9.—In either of the following cases the justice or judge must make an order vacating the award, upon the application of any party to the arbitration:

(*a*) Where the award was procured by corruption, fraud or undue means.

(*b*) Where there was evident partiality or corruption in the arbitrators, or either of them.

(*c*) Where the arbitrators were guilty of misconduct, in refusing to postpone the hearing, upon sufficient cause shown, or in refusing to hear evidence pertinent and material to the controversy; or of any other misbehaviors, by which the rights of any party have been prejudiced.

(*d*) Where the arbitrators exceeded their powers, or so imperfectly executed them, that a mutual, final and definite award, upon the subject matter submitted, was not made.

Where an award is vacated and the time, within which the agreement required the award to be made, has not expired, the court may, in its discretion, direct rehearing by the arbitrators.

When Award May Be Modified

10.—In either of the following cases the court must make an order modifying or correcting the award, upon the application of any party to the arbitration:

(*a*) Where there was an evident miscalculation of figures, or an evident mistake in the description of any person, thing or property, referred to in the award.

(*b*) Where the arbitrators have awarded upon a matter not submitted to them, unless it is matter affecting the merits of the decision upon the matters submitted.

(*c*) Where the award is imperfect in a matter of form, not affecting the merits of the controversy.

The order must modify and correct the award, so as to effect the intent thereof, and promote justice between the parties.

Notice to Vacate Award; How Served

11.—Notice of a motion to vacate, modify or correct an award must be served upon the adverse party, or his attorney, within three months after award is filed or delivered as prescribed by law for service of notice of a motion in an action. For the purposes of the motion any judge who might make an order to stay the proceedings, in an action brought in the same court, may make an order to be served with the notice of motion, staying the proceedings of the adverse party to enforce the award.

Judgment Upon Award

12.—Upon the granting of an order confirming, modifying or correcting an award, judgment may be entered in conformity therewith in the court wherein the justice or judge making the same sits.

Papers to Be Filed with Clerk

13.—The party moving for an order confirming, modifying or correcting an award shall at the time such order is filed with the clerk for the entry of judgment thereon, also file the following papers with the clerk:

(*a*) The submission; the selection or appointment, if any, of an additional arbitrator or umpire, and each written extension of the time, if any, within which to make the award.

(*b*) The award.

(*c*) Each notice, affidavit or other paper used upon an application to confirm, modify or correct the award, and a copy of each order made upon such an application.

The judgment may be docketed, as if it was rendered in an action.

14.—The judgment so entered has the same force and effect, in all respects, as, and is subject to all the provisions of law relating to, a judgment in an action; and it may be enforced, as if it had been rendered in an action in the Court in which it is entered.

Appeal

15.—An appeal may be taken from an order confirming, modfying, correcting or vacating an award, or from a judgment entered upon an award, as from an order of judgment in an action.

Repealer and Application of Act

16.—All acts and parts of acts inconsistent with this act are hereby repealed, and this act shall take effect on and after the fourth day of July next

after its enactment, but shall not apply to contracts made prior to the taking effect thereof.

Approved March 21, 1923.

APPENDIX II

STANDARD ARBITRATION CLAUSE FOR INSERTION IN CONTRACTS

The text of the following proposed standard arbitration clause, enforceable both under the Federal and the State laws mentioned previously, is adapted from the clause heretofore found effective by the Arbitration Society of America under the New York State Law:

Any claim or dispute arising under this contract or for the breach thereof shall be submitted to arbitration in conformity with the arbitration statutes, Federal or State, as the case may be, and in accordance with the rules, then obtaining, of the Arbitration Society of America (or substitute the name of any other responsible organization).

APPENDIX III

RULES OF THE ARBITRATION SOCIETY OF AMERICA

Explanation: It will be noted that the typical arbitration clause quoted in Appendix II, specifies that arbitration is to be under the rules of the Arbitration Society of America. It is important that this provision be made or that it be stipulated that arbitration shall proceed under the rules of some other arbitral or commercial organization. The reason for this is that the laws as passed do not cover arbitration procedure in all particulars. Therefore, if competent rules are not specified as governing the arbitration there may be delay and even controversy as to procedure. Competent rules may be drawn up by any well informed body, such as a local Bar Association, or a trade association, provided it have the assistance of counsel experienced in arbitration.

The rules of the Arbitration Society of America, which follow, have been drawn up with great care and are designed to cover the important items likely to arise in procedure.

Rules*

The object of arbitration is the speedy determination, in accordance with arbitration laws, of controversies between parties by arbitrators of their own selection or appointed pursuant to the arbitration laws, on the basis of justice and equity, thereby affording an inexpensive and practical method of adjudication.

I.—Appointment of Arbitrators.—The parties may agree upon one or more arbitrators. The Arbitration Committee of the Society will select, designate

* If these rules be used as a model for the rules of some other organization, the name of that body will be substituted for that of the Arbitration Society of America.

and appoint one or more arbitrators at the request of both the parties, or when so requested by either of the parties, where such arbitration is had pursuant to their previous written agreement providing for arbitration in case of dispute, and they fail to agree upon the arbitrators when so requested by either of the parties.

II.—Chairman.—If three or more arbitrators are chosen, the parties shall designate one of them as chairman. If not so designated by the parties, the chairman shall be designated by the Arbitration Committee of the Society.

III.—Vacancies.—The Arbitration Committee shall have power and authority to declare the position of any arbitrator vacant by reason of sickness, death, resignation, absence, disqualification, neglect, refusal, or inability to act, and any such declaration of vacancy by the Arbitration Committee shall be final, conclusive and binding on all the parties. Vacancies shall be filled in the manner provided for by these rules for original appointments. Upon appointment of any new arbitrator he and the remaining arbitrators shall meet and agree as to the manner of conducting and proceeding with the arbitration in view of the substitution of arbitrator; but if the arbitrators fail, neglect or refuse to agree, within such time as the Arbitration Committee may deem reasonable, then the Arbitration Committee shall make a rule or order in accordance with which the arbitrators shall proceed; and such rule and order shall be final, conclusive and binding on all the parties.

IV.—Submissions.—All submissions shall be executed in triplicate, in form provided by law, and one of these shall be filed with the Clerk of the Arbitration Committee, duly acknowledged before a notary public or other authorized official as required by law. Where a submission is not signed by the principal, the Arbitration Committee may require such proof of the authority of the person signing on behalf of the principal, as the Arbitration Committee shall deem necessary or proper, *e. g.*:

(*a*) If signed by an agent, the original or a duly authenticated copy of his power of attorney;

(*b*) If signed by one or more partners, the written consent of co-partners not signing the submission;

(*c*) If signed in behalf of a corporation, a duly certified copy of the resolution authorizing the submission.

V.—Right of Privacy.—The hearings shall be private, unless otherwise directed by the Arbitration Committee. Such direction must be made when requested by the parties. The members of the Committee may be present at the hearings. The testimony shall not be open to others than the parties, except upon the written order of a member of the Committee, unless otherwise required by law.

VI.—Hearings.—The hearing of cases shall commence as soon as practicable after submission and shall be pressed to speedy termination.

A stenographic record of the testimony and proceedings shall not be made and is hereby waived, unless it is expressly demanded or required by a party.

VII.—Attorneys.—Either party, if he so desires, may be represented upon the arbitration by an attorney duly admitted and licensed to practice law. In that event, such attorney shall file a notice of his appearance with the Clerk in the usual form, and thereupon all notices to and service of papers upon such attorney made (in like manner as service upon an attorney in an action) shall have the same force and effect as though given to or served upon said party.

VIII.—Evidence.—While the arbitrators are not bound by the legal rules of evidence, they should exclude matters obviously unrelated which are time-consuming and becloud the issue; but all evidence bearing upon the case should be freely admitted.

Hearings not being confined by the strict legal rules of evidence, liberality of procedure is to be observed and such methods are to be followed as

will be best calculated to elicit all the evidence pertaining to the case and at the same time meet the convenience of the parties.

IX.—Conciliation.—The spirit of conciliation should guide the arbitrators in their conduct of the proceedings and they should endeavor to remove all doubts and misunderstandings between the parties so as to effect if possible a meeting of their minds.

X.—Awards.—In case an award seemingly becomes necessary, the arbitrators ought, whenever they deem it expedient, with the view of promoting a better understanding between the parties, express their reasons for the intended award. The award in its form should be definite, certain, complete and unambiguous. Each party to the arbitration shall be entitled to a copy of the award. When not otherwise provided by the terms of the submission the arbitrators shall make their award within ten days after the final hearing, unless within that time they or a majority of them give written notice to all parties naming an extension of time for making the award, and further extensions may be similarly ordered thereafter; provided, however, that the aggregate number of days for which such extensions may be made shall not exceed thirty, except by written consent of all parties or upon the written order of a member of the Arbitration Committee.

XI.—Clerk's Duties.—The Secretary of the Arbitration Society of America shall be *ex-officio* the Clerk of the Arbitration Committee. His duties as such are as follows: he shall receive and file all submissions and all copies of awards; give notice of all hearings; keep a record of all cases, and keep such other books and memoranda as the Committee shall from time to time direct; render all necessary assistance to the arbitrators; attend to their clerical work; and receive and disburse all deposits and costs and keep careful and accurate account thereof under the supervision of the Arbitration Committee; and shall perform all other services incident to his office.

XII.—Deposit.—The parties to the submission shall each deposit with the Clerk at the time of filing the submission such reasonable sum, if any, as he may deem requisite, and thereafter such further reasonable sums as the Committee may deem necessary, which shall be disbursed for the account of the parties in payment of arbitrators' and stenographers' fees, if any, and for all other necessary expenses.

XIII.—Arbitrators' Fees.—Where an arbitrator, registered with the Society to serve without compensation, is designated, there will be no fee.

Where an arbitrator, not so registered with the Society, is designated, a fee will be paid to the arbitrator by the parties to the controversy. The amount of this fee, and the conditions of its payment (whether by the party in whose favor the award is found or the party against whom the award is made, or by each of them in shares regardless of the nature of the award), will be arranged between the arbitrator (or arbitrators) and the parties to the controversy at the time of the submission, and can only be changed thereafter by their mutual consent. The Society will, as a measure of service to all concerned, conduct the negotiations and prepare the necessary written stipulation to be signed by the parties to the arbitration. In the event that such an arrangement is not entered into, the amount of the fee shall be fixed by the arbitrator but, if deemed unreasonable by the parties, the decision of the Arbitration Committee shall, in all respects, be binding and conclusive.

XIV.—Contingencies.—In case of difference as to procedure or any matter not expressly covered by these rules, or in the event of any misunderstanding or question concerning their interpretation or application, the determination of the Arbitration Committee, not contrary to express provisions of law, shall be binding and conclusive upon the parties.

XV.—Construction of Rules.—The arbitrators shall construe these rules and regard the submission to them as being designed to secure justice and equity in the shortest possible time, with a minimum of expense, and above

all, if possible, to obviate or, in any event, minimize the annoyance, irritation and bad feeling which often exists or is engendered between disputants.

XVI.—Definitions.—Wherever the word "party" or "parties" is used in the rules, it shall refer to the parties to the submission, and wherever the word "arbitrator" or "arbitrators" is used it shall refer to the arbitrator or arbitrators, as the case may be, whether there are one or more. Wherever the word "Committee" is used, it shall refer to the Arbitration Committee of the Arbitration Society of America, Inc. Wherever the word "Society" is used, it shall refer to the Arbitration Society of America, Inc. Wherever the word "Clerk" is used, it shall refer to the Clerk of the Arbitration Committee.

XVII.—Special Rules.—The Arbitration Committee may, wherever it deems it appropriate or necessary so to do, adopt special rules applicable to any particular business, trade or profession or to any particular business, trade, professional or other association; and in case of conflict or inconsistency between such special rules and the general rules, the special rules shall prevail.

XVIII.—Amendments.—The Arbitration Committee shall have full power to amend, alter, repeal, add to or omit any of these Rules from time to time as may be found expedient.

XIX.—Facilities.—The Society will provide the parties with adequate rooms, all the necessary forms and papers and stenographic and clerical service at cost and without profit and will endeavor to do, or cause to be done, everything it properly can do for the purpose of assisting the parties in reaching a speedy, economical, harmonious and just determination of the matter in dispute.

Progress Report of Special Committee to Report on Stresses in Railroad Track*

THE BOARD OF DIRECTION,

AMERICAN SOCIETY OF CIVIL ENGINEERS:

The Special Committee to Report on Stresses in Railroad Track, co-operating with a similar Committee of the American Railway Engineering Association and the American Railway Association, presents the following report of progress.

During 1925 experimentation was directed on the rail joint in an effort to determine the intensity and distribution of the stresses in the splice-bar and in the rail at the joint, the characteristics of the flexural action for different forms of splice-bar, and the effect of varying conditions in the joint, such as the tension of the bolts and the fit of the splice-bar to the rail. An effort was also made to learn to what extent the stresses and moments developed varied from joint to joint in the track and whether the joints in service behaved in accordance with assumptions quite commonly made.

The experimental work in the laboratory under controlled conditions permitted the measurement of the strains in the various parts of the angle-bar or other form of splice-bar under bending loads, the measurement of the tension of the bolts tightened under different degrees of torque and the effect on the corresponding flexural stresses in the splice-bar, and the observation of the position of the bearing areas and the effect of the fit of the splice-bar against the rail and also the effect of the vertical deflection and play of the splice-bar and of its lateral bending and twisting. This work has given information which it is thought will have an important bearing on the design of the form of the splice-bar and on the analysis of its action under load.

Field tests were conducted on the track of the Illinois Central Railroad at Champaign, Ill., the Delaware, Lackawanna and Western Railroad at Dover, N. J., and the Nashville, Chattanooga and St. Louis Railroad at Bass, Ala. The rail was 90-lb., 130-lb., and 110-lb. The joints were tested as found in the track, loads of from 95 000 to 127 000 lb. on a four-wheel truck of a freight car being applied and also in some tests lighter loads. Measurements were made of strains at certain gauge lines on the splice-bars and rails, tension in the bolts, and deflections at the joints and for given distances on each side of the rail end. Although the nature and extent of the tests differed at the three locations, the following may give an idea of the variation in the conditions of the tests: Tight and loose bolts; tightness of bolt obtainable by track wrench in the hands of the trackman; loose tie and freshly tamped tie; good and bad fit of angle-bar; special forms of angle-bar; and relative tension in bolts at joints where rails had been slipping with changes in temperature and at joints that had not moved under the same conditions of temperature.

* Presented to the Annual Meeting, January 20, 1926.

Progress has been made in reducing data and preparing the material, but the work is not yet ready for presentation. It is found that the resisting moment developed in the rail joint under load in the track varies greatly from joint to joint and an effort is being made to learn the principal sources of this variation. As may have been expected from analytical considerations, the neutral axis of the angle-bars deflects from the horizontal and the stresses at the outer edge of the flange of the angle-bar are frequently very low, especially with loose bolts or poor fit between bar and rail. In several ways the results may be expected to lead to a discussion whether improvements in the design of the rail joint may be made.

The Committee has a number of other questions under consideration.

Respectfully submitted,

The Special Committee on Stresses in Railroad Track

A. N. Talbot, *Chairman*

G. H. Bremner,	George W. Kittredge,
John Brunner,	Paul M. LaBach,
W. J. Burton,	C. G. E. Larsson,
Charles S. Churchill,	G. J. Ray,
W. C. Cushing,	Albert F. Reichmann,
W. M. Dawley,	H. R. Safford,
C. W. Gennet, Jr.,	Earl Stimson,
H. E. Hale,	F. E. Turneaure,
J. B. Jenkins,	J. E. Willoughby.

January 20, 1926.

Progress Report of the Special Committee on Effects of Earthquakes on Engineering Structures with Special Reference to the Japanese Earthquake of September 1, 1923*

To the Board of Direction,
American Society of Civil Engineers:

The following may be taken as a progress report of the work of the Earthquake Committee.

All the data have now been received from Japan, the last package coming in about two weeks ago. These data are very complete and are accompanied by text which is being translated by Mr. James F. Abbott.

In addition to the Japanese data the Committee has accumulated a large amount of data from American engineers and is now studying the general subject of earthquakes apart from the *Bulletins* of the Seismological Society of America.

All the material has been indexed and will be made use of in the preparation of the report. It is the intention to cover in a reasonable degree, all phases of the subject of earthquakes and for this reason some time must yet elapse before the report will be ready.

For the Committee on Effects of Earthquakes on Engineering Structures,

By J. D. Galloway,
Chairman.

December 17, 1925.

* Presented to the Annual Meeting, January 20, 1926.

Progress Report of
Special Committee on Engineering Contract Bonding*

To the Board of Direction,
American Society of Civil Engineers:

Gentlemen.—Your Committee on Contract Bonds wishes to submit as its report the attached Standard Questionnaires and Financial Statement for Bidders, adopted at a Joint Conference on Construction Practices.

Several meetings were held consisting of representatives from the American Association of State Highway Officials, the American Institute of Architects, the American Institute of Consulting Engineers, the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Society for Municipal Improvements, the Associated General Contractors of America, the Highway Industries Exhibitors Association, the National Association of Casualty and Surety Agents and the Surety Association of America (Committee on Better Underwriting).

It was the sense of the Conference that this questionnaire be required of all bidders where their financial responsibility and experience was not known.

Your Committee respectfully recommends that the form of questionnaire attached be printed in *Proceedings* for the information of the members of the Society.

Respectfully submitted,

H. G. Shirley, *Chairman*,
J. S. Langthorn,
Frank C. Wight.

August 26, 1925.

* Presented to the Annual Meeting, January 20, 1926.

STANDARD QUESTIONNAIRES AND FINANCIAL STATEMENT FOR BIDDERS

ENGINEERING CONSTRUCTION

Approved and recommended by

THE JOINT CONFERENCE ON CONSTRUCTION PRACTICES

for use in investigating the qualifications of bidders on public and private construction.

Participating Committees

AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS:

W. R. Neel, State Highway Engr., East Point, Ga., *Chairman.*
P. St. Julien Wilson, Chief Engr., Bureau of Public Roads, Washington, D. C.
Fred R. White, Chief Engr., Iowa State Highway Comm., Ames, Iowa.
James A. French, State Highway Engr., Santa Fé, N. Mex.
H. C. Dietzer, State Highway Engr., Jackson, Miss.
L. A. Boulay, Director, Dept. of Highways and Public Works, Columbus, Ohio.
William H. Connell, Eng. Executive and Dept. Secy., Pennsylvania State Highway Dept., Harrisburg, Pa.

AMERICAN INSTITUTE OF ARCHITECTS:

T. E. Snook, 52 Vesey Street, New York, N. Y.
Victor Mindeleff, 4416 Klingle St., Washington, D. C.
Capt. Francis P. Sullivan, 1901 Columbia Rd., Washington, D. C.

AMERICAN INSTITUTE OF CONSULTING ENGINEERS:

Morris Knowles, Pres. and Chf. Engr., Morris Knowles, Inc., 507 Westinghouse Bldg., Pittsburgh, Pa.

American Society of Civil Engineers:

H. G. Shirley, Chairman, State Highway Comm., Richmond, Va., *Chairman.*

J. S. Langthorn, Pres., Langthorn & Smith, Inc., 120 Liberty St., New York, N. Y.
Frank C. Wight, Editor, *Engineering News-Record,* Tenth Ave. at 36th St., New York, N. Y.

American Society of Mechanical Engineers:

R. C. Marshall, Jr., Gen. Mgr., Associated General Contractors of America, Washington, D. C.

American Society for Municipal Improvements:

W. W. Horner, Chf., Div. of Sewers and Paving, St. Louis, *Chairman.*
E. S. Rankin, Engr. in Chg., Bureau of Sewers, Newark, N. J.

Associated General Contractors of America:

H. H. Wilson, Winston & Co., Harrisburg, Pa., *Chairman.*
F. L. Cranford, 149 Remsen Street, Brooklyn, N. Y.
L. C. Wason, Aberthaw Co., 80 Federal St., Boston, Mass.
D. B. Fegles, Fegles Const. Co., 706 First Ave., N., Minneapolis, Minn.
H. S. Tullock, Missouri Valley Bridge & Iron Co., Leavenworth, Kans.
W. A. Simpson, Wm. Simpson Const. Co., Guaranty Bldg., Los Angeles, Calif.
George Watson, The Watson Co., 1927 S. Akard St., Dallas, Tex.

Highway Industries Exhibitors Association:

S. M. Williams, Autocar Sales & Service Co., Ardmore, Pa.
Lion Gardner, Lakewood Eng. Co., Cleveland, Ohio.
Philip Koehring, Koehring Co., Milwaukee, Wis.
Chester H. Lehman, Blaw-Knox Co., Pittsburgh, Pa.
R. H. Hillis, Dexter Portland Cement Co., 350 Madison Ave., New York, N. Y.
G. W. Craig, Mgr., The Asphalt Assoc., 729 Hearst Bldg., Chicago, Ill.

National Association of Surety and Casualty Agents:

J. W. Henry, Pres., National Assoc. of Surety and Casualty Agts., Pittsburgh, Pa.

Surety Association of America (Committee on Better Underwriting)

First Edition, 1925
Issued by the Joint Conference on Construction Practices
1035 Munsey Building, Washington, D. C.

EXPLANATORY

Though the laws governing public contracts provide, with few exceptions, that such contracts shall be awarded to the lowest responsible bidder, there has been no generally recognized legal interpretation of the term "responsible bidder" and it is commonly accepted as meaning any bidder who can supply a surety bond. That the furnishing of a bond does not necessarily indicate responsibility is generally known. The surety company has not presumed to guarantee that the bidders whom it bonds are responsible but merely that their contract obligations will by some means be fulfilled. Consequently the ability of a bidder to execute his obligations has in general received insufficient attention and each year public construction has been subject to loss and delays from thousands of defaulted contracts.

In response to the needs generally voiced by engineers, architects and public officials, for some means whereby they may gauge the responsibility of bidders, this subject has been extensively investigated by the Joint Conference on Construction Practices, representing practically all of the elements concerned with the design, management, supervision and financing of construction. It obtained information from practically every State with respect to the methods in use for ascertaining a bidder's character, experience, organization and financial condition. Upon the basis of this information, which shows that various public construction agencies, especially State highway departments, are successfully using sworn questionnaires and financial statements, the Conference has developed two sets of forms, one for building and one for engineering construction.

The forms consist of a financial statement, which indicates the bidder's financial standing, an experience questionnaire designed to reveal his past record, and a plan and equipment questionnaire giving certain information with respect to his qualifications for undertaking a specific project. Each of these forms is accompanied by an affidavit, so that information presented in them is given under oath. The material in the questionnaires and financial statement has been drawn largely from forms already in use and has been subjected to careful criticism by engineers, architects, contractors, surety officials, manufacturers and bankers.

Some division of opinion exists with respect to the practice of using such forms, as, for example, whether the financial statement should be required from every bidder with his proposal or from the three low bidders only, but the Conference is unanimous in the belief that the complete forms should accompany the instructions to bidders with definite notice of the procedure to be followed.

Among the significant benefits to be derived from the standard forms are: the ease with which reliable information can be exchanged by public officials; and the saving of time and expense to construction companies who bid on the work of many different departments. Uniformity in financial statements is considered especially important, not only because of the economy factor but also because of its influence in encouraging uniform and adequate accounting among construction companies.

The accompanying forms are unqualifiedly recommended by the Joint Conference for use in connection with the award of either public or private contracts and it urges that they be given an immediate and thorough test. Any modifications shown by experience to be advisable can then be made.

EXPERIENCE QUESTIONNAIRE

Approved and recommended by the
Joint Conference on Construction Practices
for use in investigating the responsibility of bidders.

Submitted by ....

Address ....

Date ....

First Edition, 1925
Issued by the Joint Conference on Construction Practices
1035 Munsey Building, Washington, D. C.

EXPERIENCE QUESTIONNAIRE

Submitted to..

By .... ☐ A Corporation / ☐ A Co-partnership / ☐ An Individual

Principal Office..

The signatory of this Questionnaire guarantees the truth and accuracy of all statements and of all answers to interrogatories hereinafter made.

1. How many years has your organization been in business as a general contractor under your present business name?..........................

2. How many years experience in............construction work has your organization had: (a) As a general Contractor................(b) as a Sub-Contractor...............

3. What projects has your organization completed?

Contract Amt.	Class of Work	When Completed	Name and Address of Owner
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

4. Have you ever failed to complete any work awarded to you?............ If so, where and why?..

....

....

....

5. Has any officer or partner of your organization ever been an officer or partner of some other organization that failed to complete a construction contract?................ If so, state name of individual, other organization and reason therefor..

....

....

6. Has any officer or partner of your organization ever failed to complete a construction contract handled in his own name?................ If so, state name of individual, name of Owner and reason therefor..............................

....

....

....

7. In what other lines of business are you financially interested?..........

....

....

....

8. For what corporations or individuals have you performed work, and to whom do you refer?..

....

....

....

....

....

....

9. For what cities have you performed work and to whom do you refer?
....
....
....
....
....

10. For what counties have you performed work and to whom do you refer?
....
....
....
....
....
....

11. For what State Bureaus or Departments have you performed work and to whom do you refer?..
....
....
....
....
....
....

12. Have you ever performed any work for the U. S. Government?........
If so, when and to whom do you refer?..................................
....
....
....
....
....
....

13. What is the construction experience of the principal individuals of your organization?

Individual's Name	Present Position or Office	Years of Construction Experience	Magnitude and Type of Work	In What Capacity
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....

Dated at......................................this...............
day of...................19.....

....
Name of Organization

By ....
....
Title of Person Signing

STATE OF........................} ss.:
County of......................}

..............................being duly sworn deposes and says that he is .... of ....
Name of Organization

and that the answers to the foregoing questions and all statements therein contained are true and correct.

Sworn to before me this

..............day of..................19....

....
Notary Public

My commission expires..........................

PLAN AND EQUIPMENT QUESTIONNAIRE

FOR ENGINEERING CONSTRUCTION

Approved and recommended by the Joint Conference on Construction Practices for use in investigating the qualifications of bidders with respect to a specific project.

Project ....

Location ....

Date of Letting..................................

Submitted by....................................

Address ....

First Edition, 1925
Issued by the Joint Conference on Construction Practices
1035 Munsey Building, Washington, D. C.

PLAN AND EQUIPMENT QUESTIONNAIRE

Submitted to ....

By .... { ☐ Corporation / ☐ Co-partnership / ☐ An individual }

Principal Office ....

The signatory of this questionnaire guarantees the truth and accuracy of all statements and of all answers to interrogatories hereinafter made.

1. In what manner have you inspected this proposed work? Explain in detail.

....

2. Explain your plan or lay out for performing the proposed work........

....

3. The work, if awarded to you, will have the personal supervision of whom?

....

4. Do you intend to do the hauling on the proposed work with your own forces? ....
If so, give amount and type of equipment to be used........................

....

5. If you intend to sublet the hauling or perform it through an agent, state amount of sub-contract or agent's contract, and, if known, the name and address of sub-contractor or agent, amount and type of his equipment and his financial responsibility..

....

6. Do you intend to do the grading on the proposed work with your own forces? ....
If so, give type of equipment to be used..

....

7. If you intend to sublet the grading or perform it through an agent, state amount of sub-contract or agent's contract, and, if known, the name and address of sub-contractor or agent, amount and type of his equipment and his

financial responsibility ....
....
....
....
....
....

8. Do you intend to sublet any other portions of the work? .... If so, state amount of sub-contract, and, if known, the name and address of the sub-contractor, amount and type of his equipment and his financial responsibility ....
....
....
....
....
....
....

9. From which sub-contractors or agents do you expect to require a bond?
....
....
....
....

10. What equipment do you own that is available for the proposed work?

Quantity	Item	Description, Size, Capacity, Etc.	Condition	Years of Service	Present Location
......	......	....	.....	.....	....
......	......	....	.....	.....	....
......	......	....	.....	.....	....
......	......	....	.....	.....	....
......	......	....	.....	.....	....
......	......	....	.....	.....	....
......	......	....	.....	.....	....
......	......	....	.....	.....	....
......	......	....	.....	.....	....
......	......	....	.....	.....	....
......	......	....	.....	.....	....
......	......	....	.....	.....	....
......	......	....	.....	.....	....
......	......	....	.....	.....	....
......	......	....	.....	.....	....

11. What equipment do you intend to purchase for use on the proposed work, should the contract be awarded to you?

Quantity	Item	Description, Size, Capacity, Etc.	Approximate Cost
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

12. How and when will you pay for the equipment to be purchased?......

....

....

13. Do you propose to rent any equipment for this work?............. If so, state type, quantity and reasons for renting............................

....

....

....

14. Have you made contracts or received firm offers for all materials within prices used in preparing your proposal? Do not give name of dealers or manufacturers ....

....

....

Dated at...................................this................day of ....19...

....

Name of Organization

By ....

....

Title of Person Signing

STATE OF ....} ss.
County of ....}

..........................being duly sworn deposes and says that he is....................of..

Name of Organization

and that the answers to the foregoing questions and all statements therein contained are true and correct.

Sworn to before me this

................day of..................19....

....

Notary Public

My Commission expires...........................

STANDARD FORM OF

CONTRACTOR'S FINANCIAL STATEMENT

Approved and recommended by the Joint Conference on Construction Practices for use in investigating the qualifications of bidders on public and private construction.

Submitted by.......................................

Address ....

Date ....

First Edition, 1925
Issued by the Joint Conference on Construction Practices
1035 Munsey Building, Washington, D. C.

CONTRACTOR'S FINANCIAL STATEMENT

APPROVED AND RECOMMENDED FOR USE BY THE JOINT CONFERENCE ON CONSTRUCTION PRACTICES

Submitted by.................................. { ☐ An Individual ☐ A Co-partnership ☐ A Corporation }

With principal office at..

To ....

Condition at close of business.........................19....

ASSETS	Dollars	Cts.
1. Cash: (a) On hand $..........., (b) In bank $...........,	....	..
(c) Elsewhere $..........	....	..
2. Notes receivable		
(a) Due within 90 days.......................................	....	..
(b) Due after 90 days..	....	..
(c) Past due..	....	..
3. Accounts receivable from completed contracts, exclusive of claims not approved for payment..................	....	..
4. Sums earned on uncompleted contracts as shown by Engineer's or Architect's estimate		
(a) Amount receivable after deducting retainage........	....	..
(b) Retainage to date, due upon completion of contracts..	....	..
5. Accounts receivable from sources other than construction contracts	....	..
6. Deposits for bids or other guarantees:		
(a) Recoverable within 90 days..............................	....	..
(b) Recoverable after 90 days................................	....	..
7. Interest accrued on loans, securities, etc..................	....	...
8. Real estate:		
(a) Used for business purposes..............................	....	..
(b) Not used for business purposes..........................	....	..
9. Stocks and bonds:		
(a) Listed—present market value.............................	....	..
(b) Unlisted—present value...................................	....	..
10. Materials in stock not included in Item 4		
(a) For uncompleted contracts (present value)..........	....	..
(b) Other materials (present value)........................	....	..
11. Equipment, book value..	....	..
12. Furniture and fixtures, book value..........................	....	..
13. Other assets...	....	..
Total assets	....	..

LIABILITIES	Dollars	Cts.
1. Notes payable:		
(a) To banks regular	....	..
(b) To banks for certified checks	....	..
(c) To others for equipment obligations	....	..
(d) To others exclusive of equipment obligations	....	..
2. Accounts payable:		
(a) Not past due	....	..
(b) Past due	....	..
3. Real estate encumbrances	....	..
4. Other liabilities	....	..
5. Reserves	....	..
6. Capital stock paid up:		
(a) Common	....	..
(b) Common	....	..
(c) Preferred	....	..
(d) Preferred	....	..
7. Surplus (net worth)	....	..
Total liabilities	....	..

CONTINGENT LIABILITIES		
1. Liability on notes receivable, discounted or sold	....	..
2. Liability on accounts receivable, pledged, assigned or sold	....	..
3. Liability as bondsman	....	..
4. Liability as guarantor on contracts or on accounts of others	....	..
5. Other contingent liabilities	....	..
Total contingent liabilities	....	..

DETAILS RELATIVE TO ASSETS

1 Cash:

(a) on hand.. $..........

(b) deposited in banks named below.................. $..........

(c) elsewhere—(state where)......................... $..........

Name of Bank	Location	Deposit in Name of	Amount
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

2* Notes receivable:

(a) due within 90 days............................. $..........

(b) due after 90 days.............................. $..........

(c) past due....................................... $..........

Receivable from:	Name and Address	For What	Date of Maturity	How Secured	Amount
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....

DETAILS RELATIVE TO ASSETS (*Continued*)

Have any of the above been discounted or sold?.......... If so, state amount, to whom, and reason..
....

3* Accounts receivable from completed contracts exclusive of claims not approved for payment.................... $..........

Name and Address of Owner	Nature of Contract	Amount of Contract	Amount Receivable

Have any of the above been assigned, sold, or pledged?.......... If so, state amount, to whom, and reason..
....

4* Sums earned on uncompleted contracts, as shown by engineer's or architect's estimate:
(a) Amount receivable after deducting retainage........ $..........
(b) Retainage to date due upon completion of contract... ....

Designation of Contract and Name and Address of Owner	Amount of Contract	Amount Earned	Amount Received	Retainage: When Due	Retainage: Amount	Amount Exclusive of Retainage

Have any of the above been sold, assigned, or pledged?.......... If so, state amount, to whom, and reason..
....

5* Accounts receivable not from construction contracts... .. $..........

Receivable from: Name and Address	For What	When Due	Amount

What amount, if any, is past due........................ $..........

* List separately each item amounting to 10 per cent. or more of the total and combine the remainder.

DETAILS RELATIVE TO ASSETS (*Continued*)

6 Deposits with bids or otherwise as guarantees..............................

Deposited with: Name and Address	For What	When Recoverable	Amount
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

7 Interest accrued on loans, securities, etc................. $..........

On What Accrued	To Be Paid When	Amount
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....

8 Real Estate (a) Used for business purposes................. $..........
Book Value (b) Not used for business purposes............ ....

	Description of Property	Improvements: Nature of Improvements	Improvements: Book Value	Total Book Value
1	....	....	....	....
2	....	....	....	....
3	....	....	....	....
4	....	....	....	....
5	....	....	....	....
6	....	....	....	....
7	....	....	....	....

	Location	Held in Whose Name	Assessed Value	Amount of Encumbrances
1	....	....	....	....
2	....	....	....	....
3	....	....	....	....
4	....	....	....	....
5	....	....	....	....
6	....	....	....	....
7	....	....	....	....

DETAILS RELATIVE TO ASSETS (*Continued*)

9 Stocks and Bonds:
(a) Listed—present market value.................... $..........
(b) Unlisted—present value.......................... $..........

	Description	Issuing Company	Last Int. or Div. Paid. Date	%	Par Value	Present Market Value	Quantity	Amount
1	....	....	....	..	....	.....	....	......
2	....	....	....	..	....	.....	....	......
3	....	....	....	..	....	.....	....	......
4	....	....	....	..	....	.....	....	......
5	....	....	....	..	....	.....	....	......
6	....	....	....	..	....	.....	....	......
7	....	....	....	..	....	.....	....	......

	Who Has Possession	If Any are Pledged or in Escrow, State for Whom and Reason	Amount Pledged or in Escrow
1	....	....	....
2	....	....	....
3	....	....	....
4	....	....	....
5	....	....	....
6	....	....	....
7	....	....	....

10 Materials in stock and not included in Item 4, Assets:
(a) For use on uncompleted contracts (present value).... $..........
(b) Other materials (present value)...................... $..........

Description of Material	Quantity	Present Value: For Uncompleted Contracts	Present Value: Other Materials
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

DETAILS RELATIVE TO ASSETS (*Continued*)

11* Equipment at book value.. $..........

Quantity	Description and Capacity of Items	Age of Items	Purchase Price	Depreciation Charged Off	Book Value
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
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....	....	....	....	....	....

Are there any liens against the above?...............If so, state total amount.. $..........

12 Furniture and fixtures at book value.................. $............

13 Other assets.. $..........

Description	Amount
....	....
....	....
....	....

Total Assets.............................. $..........

* If two or more items are lumped above, give the sum of their ages.

DETAILS RELATIVE TO LIABILITIES

1 Notes payable:
(a) To banks, regular.............................. $..........
(b) To banks for certified checks.................. $..........
(c) To others for equipment obligations.............. $..........
(d) To others exclusive of equipment obligations......... $..........

To Whom: Name and Address	What Security	When Due	Amount
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

2 Accounts payable:
(a) Not past due.................................. $..........
(b) Past due...................................... $..........

To Whom: Name and Address	For What	Date Payable	Amount
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

3. Real estate encumbrances (See Item 8, Assets)............ $..........

4 Other liabilities.. $........

Description	Amount
....	....
....	....
....	....

5 Reserves.. $..........

Interest	Insurance	Bldgs. & Fixt.	Plant Depr.	Taxes	Bad Debts		
$.......	$......	$.......	$......	$......	$......	$......	$......

DETAILS RELATIVE TO LIABILITIES (*Continued*)

6 Capital stock paid up:
(a) Common .... $
(b) Preferred .... $

7 Surplus .... $..........

Total Liabilities.. $..........

If a corporation, answer this:	**If a co-partnership, answer this:**
Capital paid in cash, $..............	Date of organization................
When incorporated	State whether partnership is general, limited or association..............
In what State........................	....
President's name.....................	Name and address of partners: Age
Vice-President's name................	....
Secretary's name.....................	....
Treasurer's name.....................	....

The undersigned hereby declares: that the foregoing is a true statement of the financial condition of the individual, co-partnership or corporation herein first named, as of the date herein first given; that this statement is for the express purpose of inducing the party to whom it is submitted to award the submitter a contract; and that any depository, vendor or other agency herein named is hereby authorized to supply such party with any information necessary to verify this statement.

....
....
....
....

Note: A co-partnership must give firm name and signatures of all partners. A corporation must give full corporate name, signature of official and affix corporate seal.

Affidavit for Individual

State of .... }
County of .... } ss.:

..................................being duly sworn, deposes and says that the foregoing financial statement, taken from his books, is a true and accurate statement of his financial condition as of the date thereof and that the answers to the foregoing interrogatories are true.

....
(Applicant must also sign here)

Sworn to before me this
........day of............19
....
Notary Public

Affidavit for Co-partnership

State of ....}
County of ....} ss.:

....being duly sworn, deposes and says that he is a member of the firm of....................................; that he is familiar with the books of the said firm showing its financial condition; that the foregoing financial statement, taken from the books of the said firm, is a true and accurate statement of the financial condition of the said firm as of the date thereof and that the answers to the foregoing interrogatories are true.

....
(Members of firm must also sign here)

Sworn to before me this
........day of............19

....
Notary Public

Affidavit for Corporation

State of ....}
County of ....} ss.:

....being duly sworn, deposes and says that he is.................of the....................................the corporation described in and which executed the foregoing statement; that he is familiar with the books of the said corporation showing its financial condition; that the foregoing financial statement, taken from the books of the said corporation, is a true and accurate statement of the financial condition of the said corporation as of the date thereof and that the answers to the foregoing interrogatories are true.

....
(Officer must also sign here)

Sworn to before me this
........day of............19

....
Notary Public

Engineering Societies Library

The services of the Engineering Societies Library are available to all members who wish searches, copies, translations, etc., or advice on technical literature. A collection of modern books is also available for loan to members in North America, at moderate rentals. Correspondence should be addressed to the Director, Engineering Societies Library, 29 West 39th Street, New York, N. Y., who will gladly give information concerning the charges for the various kinds of work. A more comprehensive statement in regard to this matter will be found on pages 71 and 72 of the Year Book for 1925.

Book Notices*

(January 1 to January 30, 1926)

Architectural Iron Design and Detailing, as Required by the Laws of New York. By Daniel M. Driscoll. N. Y., D. Van Nostrand Co., 1926. 349 pp., illus., pl., tab., 8 x 11 in., cloth. $4.00.

The subjects covered are the designing and detailing of stairs, elevator drip pans, door bucks, door saddles, doors, gratings, sidewalk gratings and other miscellaneous metal work, and fire-escapes, and the fabricating and setting of light structural steel. Appendices give useful tables, cuts of stock ornamental moulding and shapes, the Building Code of New York City, the Tenement House Law and Labor Law of New York State, the Code of Ordinances and the Rules of the Board of Standards and Appeals of New York City, and a glossary. The book is intended for draftsmen, and should be particularly useful because of its careful attention to the laws governing the design of the articles discussed.

Bureau of Standards. By Gustavus A. Weber. (Institute for Government Research. Service Monographs, No. 35). Balt., Johns Hopkins Press, 1925. 299 pp., illus., 9 x 6 in., cloth. $2.00.

The history, activities and organization of the Bureau of Standards are presented in detail, together with a complete account of its purpose, its achievements and their cost. The laws governing it, the character of its plant, its functions and its personnel are described, and a full bibliography of the sources of information bearing on it is given.

Condensed Collection of Thermodynamic Formulas. By P. W. Bridgman. Cambridge, Harvard Univ. Press, 1925. 34 pp., 9 x 6 in., cloth. (Price not quoted.)

These formulas, which are intended both for students of thermodynamics and for use in practice, apply to systems for which temperature and pressure are a possible set of independent variables as well as to systems for which pressure is a function of temperature, and temperature and volume are a possible set of independent variables. The latter table applies to two-phase systems, such as water and steam in contact. Illustrative examples show how the tables are used. The author also shows how to extend the tables to systems subjected to other external forces than a hydrostatic pressure.

Die Dinpassungen und Ihre Anwendung. By K. Gramenz. Second Edition. (Dinbuch 4). Berlin, Beuth-Verlag, 1925. 219 pp., diagrams, tab., 8 x 6 in., cloth. 5,50 mk.

A manual on the standard tolerances adopted by the German Committee on Standards, the author explains the theory underlying them, shows how they are to be used in design and in practice, and discusses various details of importance.

Draft and Capacity of Chimneys. By J. G. Mingle. N. Y., Combustion Pub. Co.; D. Van Nostrand Co., 1925. 339 pp., diagrams, tab., 8 x 5 in., cloth. $3.50.

This book, which appeared serially in *Combustion*, is intended as an aid to designers of power plants in determining the proper size for chimneys, and to operators who wish to investigate the efficiency of existing chimneys. The subject is first considered theoretically and the results modified in the light of experimental data to conform with practice. The book brings together scattered available information and arranges it logically.

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* The statements made in these notices are taken from the books themselves, and this Society is not responsible for them. Unless otherwise specified, the books in this list have been donated by publishers.

Einflüsse auf Beton. Edited by A. Kleinlogel. Berlin, Wilhelm Ernst & Sohn, 1925. 452 pp., 10 x 7 in., paper. 19,50 mk; bound 21,60 mk.

Scattered information on the effect of various substances on concrete, cement, mortar, and reinforced concrete is collected in this volume. The material, collected from periodicals and books, is arranged in dictionary form under appropriate headings, with adequate cross-references, so that consultation is easy. The book will interest those in need of information on the action of acids, oils, alkalis, vapors, water, stored substances, etc., on masonry structures.

First Course in Statistical Method. By G. Irving Gavett. N. Y., McGraw-Hill Book Co., 1925. 358 pp., diagrams, tab. 9 x 6 in., cloth. $3.50.

This textbook is based on several years' experience in teaching statistical methods to students of Business Administration, Commercial Engineering, Mathematics, and other sciences at the University of Washington. The course is confined to fundamentals and is intended as an introduction to specialized courses in various fields. It assumes no knowledge of advanced mathematics.

Hütte, des Ingenieurs Taschenbuch, Vol. 1. By Akademischen Verein Hütte. Berlin, Wilhelm Ernst & Sohn, 1925. 1080 pp., diagrams, tab., 8 x 5 in., cloth. 13,20 mk.

The new edition shows further important changes and novelties. An attempt has been made to collect the theoretical principles of all engineering in Vol. 1, and this has necessitated some re-arrangement. A new section, Technical Physics, has been added, and new chapters provided on Nomography and the Kinetics of Gearing. All sections have been carefully revised and new standards have been adopted.

Industrial Fermentations. By Paul W. Allen. N. Y., Chemical Catalog Co., 1926. 424 pp., illus., diagrams, tab., 9 x 6 in., cloth. $5.00.

This author presents herein information concerning the application of micro-organisms to industry and describes their use in a wide variety of manufactures, sewage disposal, wood preservation, and the purification of water. Numerous lists of references are included. The book is designed to call attention to the wide variety of important industrial applications of micro-organisms and to indicate their relation to various industries.

Principles and Practice of Surveying, Vol. 2; Higher Surveying. By Charles B. Breed and George L. Hosmer. Third Edition. N. Y., John Wiley & Sons, 1926. 489 pp., illus., diagrams, maps, tab., 7 x 5 in., fabrikoid. $3.50.

This volume is chiefly devoted to a consideration of the various methods for conducting topographic and hydrographic surveys. The chapters on Triangulation, Astronomical Observations for Azimuth, Precise and Trigonometric Leveling, and Hydrographic Surveying have been revised to accord with present geodetic practice, and a chapter on Aerial Photographic Surveying has been added.

Six-Place Tables; with Explanatory Notes by Edward S. Allen. Second Edition. N. Y., McGraw-Hill Book Co., 1925. 144 pp., tab., 7 x 4 in., fabrikoid. $1.25.

Of pocket size, this book contains those tables that are in constant use by engineering students and, to a certain extent, by practicing engineers. Tables of natural logarithms, exponential and hyperbolic functions, and integrals have been added to this edition, as well as an introduction on the theory of logarithms and the use of the tables.

Statement and Engineering Report Submitted to the International Joint Commission Respecting the Proposal to Develop the St. Lawrence River, 1921. By Hydro-Electric Power Commission of Ontario. Toronto, 1925. 119 pp., plans, maps, tab., 10 x 7 in., cloth. $7.50.

When the International Joint Commission was empowered, in 1920, by the Governments of Canada and the United States to make a special investigation respecting the improvement of the St. Lawrence River, the Hydro-Electric Power Commission of Ontario arranged that the information which it already possessed, should be supplemented with the information obtained by additional research and the whole reduced to a report intended to help the International Joint Commission in its investigation. This report, which had never been printed, is directed to plans for power development, but the improvements are planned, it is stated, to safeguard navigation.

Strength of Materials; a Treatise on the Theory of Stress Calculations for Engineers. By John Case. N. Y., Longmans, Green & Co.; Lond., Edward Arnold Co., 1925. 558 pp., diagrams, tab., 9 x 6 in., cloth. $10.00.

This work is one in which the student can begin and complete his studies. It covers the requirements of those reading for an honors degree in English universities and is also intended to be of service as a reference textbook to the practicing engineer.

Current Civil Engineering Literature

Key to Abbreviated References to Publications Indexed*

Abbreviated References.	Publication.	Place.
Am. C. Inst.	*American Concrete Institute, Proceedings* (Y.)	Detroit
A. I. E. E.	*American Institute of Electrical Engineers Journal* (M.)	New York
A. R. E. A.	*American Railway Engineering Association, Proceedings* (Y.)	Chicago
A. S. T. M.	*American Society for Testing Materials, Proceedings* (Y.)	Philadelphia
Am. Soc. C. E.	*American Society of Civil Engineers, Proceedings* (M.)	New York
Am. Soc. Mun. Impvts.	*American Society for Municipal Improvements, Proceedings* (Y.)	New York
Am. W. W. Assoc.	*American Water Works Association, Journal* (Bi-M.)	Baltimore
Am. Wood Prs. Assoc.	*American Wood Preservers Association, Proceedings* (Y.)	Chicago
Ann. P. et C.	*Annales des Ponts et Chaussées* (Bi-M.)	Paris
Ann. T. P. Belg.	*Annales des Travaux Publics de Belgique* (Bi-M.)	Brussels
Assoc. Ing. Gand.	*Annales de l'Association des Ingénieurs sortis des Ecoles Spéciales de Gand* (Q.)	Ghent
Bost. Soc. C. E.	*Boston Society of Civil Engineers, Journal* (M.)	Boston
Can. Engr.	*Canadian Engineer* (W.)	Toronto
Cornell C. E.	*Cornell Civil Engineer* (M.)	Ithaca
Dock & Harbour	*Dock and Harbour Authority* (M.)	London
Eng.	*Engineering* (W.)	London
Eng. & Contr.	*Engineering and Contracting* (W.)	Chicago
Eng. Inst. Can.	*Engineering Institute of Canada, Journal* (M.)	Montreal
Eng. N. R.	*Engineering News-Record* (W.)	New York
Engrs. Soc. W. Pa.	*Engineers' Society of Western Pennsylvania, Journal* (M.)	Pittsburgh
Engr.	*Engineer* (W.)	London
Engrs. & Eng.	*Engineers and Engineering, Engineers' Club of Philadelphia* (M.)	Philadelphia
Gen. Civ.	*Le Génie Civil* (W.)	Paris
Gesund. Ing.	*Gesundheits Ingenieur* (W.)	Munich
Inst. C. E.	*Institution of Civil Engineers Minutes of Proceedings* (Q.)	London
Inst. Mun. & Co. Engrs.	*Institution of Municipal and County Engineers, Journal* (W.)	London
Int. Ry. Cong. Assoc.	*International Railway Congress Association, Bulletin* (M.)	Brussels
Land. Arch.	*Landscape Architecture* (M.)	Harrisburg
Mech. Eng.	*Mechanical Engineering* (M.) *Journal of the American Society of Mechanical Engineers*	New York
Mil. Engr.	*Military Engineer* (M.)	Washington
Min. & Metal.	*Mining and Metallurgy* (M.) *American Institute of Mining Engineers*	New York
Mun. & Co. Eng.	*Municipal and County Engineering* (M.)	Indianapolis
N. E. W. W. Assoc.	*New England Water Works Association, Journal* (M.)	Boston
N. Y. R. R. Club	*New York Railroad Club, Proceedings* (M.)	Brooklyn
Oest. Ing. Arch. Ver.	*Oesterreichischer Ingenieur und Architekten Verein, Zeitschrift* (F.)	Vienna
Power	*Power* (W.)	New York
Rev. Gen.	*Revue Générale des Chemins de Fer* (M.)	Paris
Ry. Age	*Railway Age* (W.)	New York
Ry. Eng. & Main.	*Railway Engineering and Maintenance* (M.)	Chicago
Ry. Rev.	*Railway Review* (W.)	Chicago
Schw. Bauz.	*Schweizerische Bauzeitung* (W.)	Zurich
Sci. Am.	*Scientific American* (M.)	New York
Soc. Ing. Civ. Fr.	*Société des Ingénieurs Civils de France, Mémoires et Comptes Rendus* (Q.)	Paris
Ver. deu. Ing.	*Verein deutscher Ingenieure, Zeitschrift* (W.)	Berlin
West. Ry. Club	*Western Railway Club, Proceedings* (M.)	Chicago
West. Soc. Engrs.	*Western Society of Engineers, Journal* (M.)	Chicago
Zeit. Bau.	*Zeitschrift fur Bauwesen* (Q.)	Berlin
Z. d. Bauver.	*Zentralblatt der Bauverwaltung* (W.)	Berlin

* Y = Yearly; Q = Quarterly; M = Monthly; F = Fortnightly; W = Weekly.

A. Applied Sciences

a. Processes of Calculation

2. Graphical and Nomographical Processes

Moments in Restrained and Continuous Beams by the Method of Conjugate Points.* Discussion: Charles S. Whitney, Edward Godfrey, Felix H. Spitzer, and C. A. P. Turner. Am. Soc. C. E. Jan., '26.

3. Stresses and Strains

The Transverse Vibration of Uniform Beams.* David M. Smith. Eng. Dec. 25, '25.

B. Applied Mechanics

a. Mechanics of Solids (Strength of Materials)

2. Elastic Solids

Theorie Generale de l'Arc Elastique Hyperstatique.* (General Theory of the Hyperstatic Elastic Arch.) D. Wolkowitsch. Gen. Civ. Serial beginning Dec. 5, '25.

6. Heterogeneous Solids (Reinforced Materials)

Stresses in Helically Reinforced Concrete Columns.* A. W. Zesiger and E. J. Affeldt. Am. Soc. C. E. Jan., '26.

b. Hydraulics

1. Processes of Measurement

Mengenmesser für strömende Flüssigkeiten und Gase.* (Flow Meter for Liquids and Gases.) Otto Böhm. Ver. deu. Ing. Dec. 5, '25.

2. Physical Hydraulics

Flow of Fluids in Curved Passages.* J. Eustice. (Paper read before British Assoc.) Eng. Nov. 13, '25.

Beobachtung wechselnder Wassermengen bei gleichen Pegelständen im Flusslauf.* (Observation on Varying Quantities of Water at Equal Water Heights in the Water Course.) Hennings. Z. d. Bauver. Dec. 9, '25.

3. Industrial Hydraulics

The Drac-Romanche Water Power Undertaking.* Eng. Dec. 25, '25.

Co-Ordination of Irrigation and Power.* Discussion: J. D. Galloway, Fred H. Tibbetts, Barry Dibble, Markham Cheever, and M. C. Hinderlider. Am. Soc. C. E. Jan., '26.

High Specific Speed Hydraulic Turbines in Their Bearing on the Proportioning of the Number of Units in Low-Head Hydro-Electric Plants. A Symposium. Discussion: W. M. White and Lewis F. Moody. Am. Soc. C. E. Jan., '26.

Kaplan and Propeller Turbines Compared.* Elov Englesson. Can. Engr. Serial beginning Jan. 5, '26.

Efficiency Test on High-Head Reaction Turbine.* Eng. N. R. Jan. 7, '26.

Development at Bonnington Falls, B. C.* Lorne A. Campbell. Can. Engr. Jan. 19, '26.

Kettenwehr, Kettenadelwehr, und selbstöffnendes Kettenadelwehr.* (Chain Weir, Chain Pin Weir, and Self-Opening Chain Pin Weir.) O. J. Herz. Oest. Ing. Arch. Ver. Nov. 27, '25.

c. Pneumatics

3. Industrial Pneumatics

The Safeguarding of Lifts. Ronald Lister. Eng. Jan. 8, '26.

C. Materials of Construction and General Processes

a. Lime, Cement, Mortar, Concrete, Brick, Bitumin, Timber, etc.

Fire-Banks for Oil Storage.* Ralph J. Reed and H. H. Hall. Am. Soc. C. E. Jan., '26.

A Method of Testing Concrete Blocks.* H. G. Lloyd. (Paper read before Inst. Struc. Engrs.) Eng. Jan. 8, '26.

Essais de Résistance à la Compression des Mortiers et Bétons. (Compressive Strength Tests of Mortars and Cements.) Gen. Civ. Dec. 19, '25.

Wirtschaftlichkeit der Mörtelbindestoffe.* (Economy of Binding Materials for Mortars.) W. Richard. Z. d. Bauver. Dec. 2, '25.

Ueber Schutzrinden von Bausteinen und ein darauf bezügliches Prüfungsverfahren.* (On Protective Coatings for Building Stones, and a Method of Testing Based Upon It.) Heinrich Seipp. Oest. Ing. Arch. Ver. Dec. 11, '25.

Die Verwendung von Fluorid zur Verbesserung von Beton.* (The Use of Fluoride for Improving Concrete.) Schmidt. Z. d. Bauver. Dec. 23, '25.

b. Metals

Verwertung von verzinktem Eisenschrott.* (Utilization of Galvanized Iron Scrap.) Oest. Ing. Arch. Ver. Dec. 11, '25.

Wechselseitige Druckversuche an Aluminum.* (Alternated Pressure Experiments on Aluminum.) G. Sachs and E. Schiebold. Ver. deu. Ing. Serial beginning Dec. 12, '25.

c. Preservation and Use of Materials, Painting, Waterproofing

Die technische Bedeutung der Dämpfungsfähigkeit eines Baustoffes.* (The Technical Importance of the Damping Properties of Structural Material.) Otto Föppl. Schw. Bauz. Dec. 5, '25.

f. Rock Excavation, Mining, Rock Removal.

L'Electrification des Houillères de Drocourt (Pas-de-Calais.)* (Electrification of the Drocourt Collieries.) Roger Valensi. Gen. Civ. Dec. 19, '25.

Messungen bei Explosionen mit Nutzanwendung auf den Bergbau.* (Measurements of Explosions with Their Application to Mining.) F. Ritter. Ver. deu. Ing. Dec. 5, '25.
Elektrisch betriebene Maschinen für die Gewinnung und Abbauförderung unter Tage.* (Electrically Operated Machines for Mining and Conveying Under Ground.) O. Popelka. Oest. Ing. Arch. Ver. Dec. 11, '25.

g. Execution of Works, Specifications

2. Of Concrete
The Effect of Moisture on Concrete.* Discussion: G. E. P. Smith. Am. Soc. C. E. Jan., '26.
Winter Concrete Must be Kept Warm.* A. M. Bouillon. Ry. Eng. & Main. Jan., '26.
5. Of Reinforced Concrete
Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete. Discussion: L. T. Guy. Am. Soc. C. E. Jan., '26.

h. Foundation, Bridge Piers, and Abutments

Modern Conceptions Concerning Foundation Engineering.* Charles Terzaghi. Bost. Soc. C. E. Dec., '25.
Little River Diversion Channel Bridge.* D. M. Scivally. Eng. & Contr. Dec. 2, '25.
Bearing-Power Tests on Deep Caisson Foundations.* Roger L. Waring and Clyde T. Morris. Eng. N. R. Jan. 21, '26.

k. Tunnels and Tunneling-Shield

Pipe Tunnel Under Gowanus Canal, Brooklyn, New York.* L. S. Stiles. Am. Soc. C. E. Jan., '26.
Running a River Through a Mountain.* J. Bernard Walker. Sci. Am. Jan., '26.
7¾-Mile Cascade Tunnel for the Great Northern Ry.* Eng. N. R. Jan. 7, '26.

D. Highways

c. Construction

Economics of Strengthening and Widening Pavements. W. H. Connell. (From paper read before Am. Assoc. State Highway Officials.) Mun. & Co. Eng. Dec., '25.
Surface Treatment of Gravel Roads with Asphaltic Oils.* J. T. Bullen. (Paper read before Fourth Asphalt Paving Conference.) Mun. & Co. Eng. Dec., '25.
Efficiency in Concrete Road Construction. J. L. Harrison. (From Public Roads.) Mun. & Co. Eng. Dec., '25.
Heavy Subgrade Soils Not Improved by Adulteration. (From report by C. L. McKesson to Calif. State Highway Engineer.) Mun. & Co. Eng. Dec., '25.
Asphaltic Pavements an Old Macadam or Gravel Bases in Grand Rapids, Mich. C. A. Paige. Mun. & Co. Eng. Dec., '25
A Heavy Pavement in a Residential Suburb.* Eng. & Contr. Dec. 2, '25.
Concrete Pavements for Streets. Clifford Older. (Paper read before Am. Soc. Mun. Impvts.) Eng. & Contr. Dec. 2, '25.
Thinner Brick for Pavements.* Webster L. Benham. (Paper read before Am. Soc. Mun. Impvts.) Eng. & Contr. Dec. 2, '25.
Design of Bituminous Pavements.* Hugh W. Skidmore. (Paper read before Am. Soc. Mun. Impvts.) Eng. & Contr. Dec. 2, '25.
Road Corrugation.* E. L. Leeming. Inst. Mun. & Co. Eng. Dec. 15, '25.
Uses of Asphalt in Road Construction. William H. Woodward. (Paper read before Fourth Annual Paving Conference.) Can. Engr. Dec. 29, '25.
The Hexagonal Slab Design of Concrete Pavement. Discussion: E. G. Hooper. Am. Soc. C. E. Jan., '26.
Scottish Rural. A Suggested Policy for the Future.* W. L. Gibson and George S. Barry. Inst. Mun. & Co. Engrs. Jan. 5, '26.
Economics of Road Surfacings.* B. Price Davies. Inst. Mun. & Co. Eng. Serial beginning Jan. 5, '26.
Tar Surface Treatment of Gravel Roads.* John S. Crandall. (Paper read before Canadian Good Roads Assoc.) Eng. & Contr. Jan. 6, '26.
High Standard Brick Pavement for Illinois.* Eng. N. R. Jan. 7, '26.
Wearing Surfaces for Concrete Bridge Floor Slabs. E. F. Kelley. Eng. N. R. Jan. 7, '26.
Gravel Roads Cheaply Surfaced with Asphalt.* Eng. N. R. Jan. 7, '26.
Widening and Thickening California Roads.* R. M. Morton and N. A. Bowers. Eng. N. R. Jan. 7, '26.
Surface Treatment of Gravel Streets.* O. F. Reynaud. Eng. & Contr. Jan. 9, '26.
Super-Highway Construction at Detroit.* Sidney D. Waldon. (Paper read before Chicago Regional Planning Assoc.) Eng. & Contr. Jan. 9, '26.
Observations on Road Corrugations. E. L. Leeming. (Paper read before Public Works, Roads and Transport Congress, London.) Can. Engr. Jan. 12, '26.
Design of Ideal Highway Pavement. A. W. Campbell. Can. Engr. Jan. 12, '26.

d. Maintenance

The Repair of Roads Against Tramway Tracks. Francis Wood. Inst. Mun. & Co. Engrs. Jan. 5, '26.
Repair and Maintenance of Old Water Bound Macadam Streets. B. C. Harvey. (Paper read before Fourth Asphalt Paving Conference.) Eng. & Contr. Jan. 6, '26.
Les Goudronnages dans l'Arrondissement de Reims et leur Adaptation au Plan de Reconstitution des Chaussées.* (Tarring Roads in the Reims District and Its Adaptation to the Plan of Reconstituting the Roads.) Maurice Briancourt. Ann. P. et C. Pt. 5, '25.

g. Machinery and Tools

Trucking within the Construction Lines of a Road Job.* L. T. Sogard. Eng. & Contr. Jan. 6, '26.

h. Vehicles, Automobiles, Traffic

The Bus as a Mass Transportation Carrier. W. W. Harris. Engrs. and Eng. Dec., '25.
The Power Plant of the Motorbus. J. C. Thirlwall. Engrs. & Eng. Dec., '25.
The Taxicab's Place in Rapid Transit. E. S. Higgins. Engrs. & Eng. Dec., '25.
Solution of Parking Problems. Roger L. Morrison. (From paper read before Nat'l Highway Traffic Assoc.) Eng. & Contr. Dec. 2, '25.
Comparison of Transportation Methods. R. A. C. Henry. (Paper read before Toronto Branch, Eng. Inst. Can.) Can. Engr. Jan. 19, '26.

E. Bridges, Viaducts, and Arches

b. Iron and Steel Bridges and Viaducts

Demolition of Niagara Falls Cantilever Bridge.* H. Ibsen. Eng. N. R. Dec. 31, '25.
Newark Bay Bridge is of Unusual Size.* Geo. E. Boyd. Ry. Rev. Jan. 16, '26.
Central of New Jersey Builds Remarkable Bridge.* Ry. Age Jan. 16, '26.

c. Stone Bridges and Viaducts

La Réfection du la Travée Centrale du Pont d'El-Kantara, à Constantine (Algérie).* Restoration of the Central Span of El-Kantara Bridge at Constantine, Algiers.) Rene Deguillaume. Gen. Civ. Dec. 12, '25.

d. Concrete and Reinforced Concrete Bridges and Viaducts

Calcul de l'Arc Circulaire Chargé d'un Remblai et d'une Charge Mobile. Application aux Conduites d'Eau en Ciment Armé.* (Calculation of a Circular Arch Loaded with an Embankment and a Mobile Load. Application to Reinforced Concrete Conduits for Water.) G. Prudon. Gen. Civ. Dec. 26, '25.

h. Computation, Tests, etc.

The Strengthening of Bridges.* C. G. Mitchell and C. S. Chettoe. Inst. Mun. & Co. Eng. Dec. 15, '25.
La Statique Grapho-Algébrique et la Méthode des Segments Appliquée au Calcul des Cadres Rectangulaires Fermés.* (Algebraic Graphical Statics and the Segment Method Applied to the Calculation of Closed Rectangular Frames.) F. Chaudy. Gen. Civ. Dec. 19, '25.

F. Inland Waters and Waterways

c. Regulation of Waterways—Volume of Discharge, Freshets, Floods, Soundings

Relation of Depth to Curvature of Channels.* H. C. Ripley. Am. Soc. C. E. Dec., '25.
The St. Lawrence Waterway to the Sea. Discussion: Elliott J. Dent, Kenneth L. DeBlois, and C. S. Riché. Am. Soc. C. E. Jan., '26.
L'Aménagement du Rhin entre Bale et Strasbourg. Le "Grand Canal" d'Alsace.* (Improvement of the Rhine between Bale and Strasbourg. The "Grand Canal" of Alsace.) Ch. Dantin. Gen. Civ. Dec. 26, '25.
Modellversuche über Strömungserscheinungen in Buhnenfeldern.* (Model Experiments on Flow Phenomena within the Field of Groins.) R. Ehrenberger. Oest. Ing. Arch. Ver. Nov. 27, '25.

d. Diverting Dams, Locks, Lifts, Elevators, Inclined Planes

Welland Canal Construction Progress.* Can. Engr. Dec. 29, '25.

g. Consolidation of Banks, Leakage, etc.

Silt and Channel Conditions in Colorado River Delta.* S. L. Rothery. Eng. N. R. Dec. 31, '25.

k. Utilization of Inland Waterways, Freight, Capacity

Relation of the Ohio River and Its Tributaries to Transportation in the United States.* A Symposium. Discussion: M. G. Barnes and C. I. Grimm. Am. Soc. C. E. Jan., '26.

G. Maritime Works

b. Management and Protection of Coasts, Beaches, Dunes

Repairs to a Quay-Wall at Key West, Fla.* E. C. Siebert. Eng. N. R. Jan. 21, '26.

c. Vessels and Maritime Navigation, Lighthouses, Buoys, Various Signals

The Behm Echo Depth-Sounder.* Eng. Serial beginning Nov. 13, '25.
Some Factors Affecting the Resistance of Ships in Waves.* W. G. A. Perring. Engr. Dec. 25, '25.
The Launch of the Airplane Carrier, U. S. S. "Saratoga".* E. H. Rigg. Eng. Jan. 8, '26.

d. Roads and Outer Harbors. Dikes and Jetties. Breakwaters

Construction of Humboldt Bay Jetties.* George F. Whittemore. Mil. Engr. Jan.-Feb., '26.
Abschluss und Trockenlegung des Zuidersee.* (Closing and Draining the Zuider Zee.) R. Schmidt. Z. d. Bauver. Dec. 16, '25.

g. Dredges and Dredging, Force Pumps, Refloating and Removing Wrecks, Ice-Breakers

Les Dragues Aspiratrices de la Mersey.* (Suction Dredges on the Mersey.) Blanquet. Ann. P. et C. Pt. 5, '25.

j. Dockyard Machinery and Shipyards, Drydocks

300-Ton Floating Crane for Handling Concrete Blocks. Eng. Dec. 25, '25.
Cranes Increase Pier Capacity Over 300 Per Cent.* Eng. N. R. Jan. 21, '26.

H. Railroads. Street and Interurban Railways. Automobiles. Aeronautics

a. Railroads

1. General Articles

Les Chemins de Fer de l'Est et la Guerre de 1914–1918. (The Eastern Railways and the 1914–1918 War.) Marcel Peschaud. Rev. Gen. Dec., '25.

3. Roadbed (Grading Construction Work)

Comparative Survey of Reduction in Grades.* C. A. Morse. Ry. Rev. Jan. 23, '26.

4. Track

Building a More Permanent Track.* Frank H. Alfred and Paul Chipman. Ry. Eng. & Main. Jan., '26.
B. R. & P. Demonstrates Economy of Tie Preservation. E. F. Robinson. Ry. Eng. & Main. Jan., '26.
Systematic Protection of Ties Effects Marked Economies.* E. F. Robinson. Ry. Age. Jan. 9, '26.

5. Signals and Safety Apparatus

Signals and Interlockers in the Chicago Union Station.* Thomas Holt. West. Soc. Engrs. Nov., '25.
Giving Trains a Radio Voice.* Orrin E. Dunlap, Jr. Sci. Am. Jan., '26.

6. Rolling Stock (Locomotives, Cars) Fuel

Locomotive Coal Trials on the Southern Railway.* H. Holcroft. Engr. Dec. 18, '25.
Brill Gas-Electric Car Has Simple Control.* Geo. E. Boyd. Ry. Rev. Dec. 26, '25.
New Gasoline Rail Car Developed.* Ry. Age Dec. 26, '25.
Oil Electric Locomotive Makes Record Run.* Ry. Age Dec. 26, '25.
Three Cylinder Locomotive Performance.* Frank E. Russell. Ry. Rev. Jan. 2, '26.
Electric Locomotives for the Lapland Railway.* Eng. Serial beginning Jan. 8, '26.
Causes and Prevention of Freight Car Derailments. T. H. Symington Ry. Age Jan. 16, '26.
Economical Locomotive Mileage between General Repairs.* Lawrence Richardson. Ry. Age Jan. 16, '26.
High Capacity Gas-Electric Car for the Seaboard.* Ry. Age Jan. 23, '26.
Automotrice à Vapeur des Chemins de Fer de la Nouvelle Zélande.* (Railway Steam Car for New Zealand.) Gen. Civ. Dec. 12, '25.
Die Schmierung der unter Dampf gehenden Teile der Heissdampflokomotive.* (The Lubrication of Parts of Superheated Steam Locomotives While in Operation.) R. P. Wagner. Ver. deu. Ing. Dec. 19, '25.

7. Use of Electricity

The Reading Gas-Electric Rail Car.* T. H. Murphy. Ry. Age Jan. 9, '26.
Electrification des Voies Ferreés d'Intérêt Local. (Electrification of Feeder Railway Lines.) Paul Dumas. Ann. P. et C. Pt. 5, '25.
Die Wirtschaftlichkeit des elektrischen Betriebes der S. B. B. nach den Erfahrungen von 1924.* (Economy of Electric Operation of the S. B. B., According to Experiences in 1924.) W. Kummer. Schw. Bauz. Dec. 12, '25.

8. Stations, Terminals, Engine Houses, Shops

The Chicago Union Station.* Joshua D'Esposito. West. Soc. Engrs. Nov., '25.
Tracks and Track Layouts in the Chicago Union Station.* Clarence J. Noland. West. Soc. Engrs. Nov., '25.
Construction Program and Method of Handling Traffic on the Chicago Union Station.* E. E. Stetson. West. Soc. Engrs. Nov., '25.
Electrical Equipment in the Chicago Union Station.* Clifford W. Post. West. Soc. Engrs. Dec., '25.
Mechanical Features of the Chicago Union Station.* Edison Brock. West. Soc. Engrs. Dec., '25.
Some Features of the Structural Design of the Chicago Union Station.* E. Weidemann. West. Soc. Engrs. Dec., '25.
New Pennsylvania Scrap Dock Saves $100 000 Per Year.* Ry. Age Jan. 9, '26.
Santa Fe Terminal Gives Dallas Prestige.* Geo. E. Boyd. Ry. Rev. Jan. 9, '26.
Improvements to Union Station at Ogden, Utah.* Eng. N. R. Jan. 21, '26.
Burlington Opens Half Million Dollar Storehouse.* Ry. Age Jan. 23, '26.
New Storehouse Has Unique Features.* L. R. Wolff. Ry. Rev. Jan. 23, '26.

b. Special Railroads

x. Miscellaneous

Die Bedeutung des Spannungsausgleich für Umkehrantriebe (Erzbergbahn, Zugspitzenbahn).* (Importance of Equalization of Tension in Reverse Drives—Mine Railways, Switchback Railways.) Otto Ohnesorge. Ver. deu. Ing. Dec. 26, '25.

d. Street Railways, Elevated Railways, Subways

5. Rolling Stock

The Motorbus as an Adjunct to the Street Railway. R. H. Horton. Engrs. & Eng. Dec., '25.

f. Aeronautics

4. Aerodromes and Landing Fields

Les Hangars d'Avions de Villacoublay.* (Aeroplane Hangars at Villacoublay.) J. Gotteland. Ann. P. et C. Pt. 5, '25.

I. Municipal Water-Works. Agricultural Engineering Irrigation

a. General Articles

The Water Works of Quebec City. J. A. Tremblay. N. E. W. W. Assoc. Sept., '25.
Lawrence Water Supply—Investigations and Construction.* Morris Knowles and Others. N. E. W. W. Assoc. Dec., '25.
Co-Ordination of Irrigation and Power.* Discussion: J. D. Galloway, Fred H. Tibbetts, Barry Dibble, Markham Cheever and M. C. Hinderlider. Am. Soc. C. E. Jan., '26.

b. Hydrology, Water Resources

Running a River Through a Mountain.* J. Bernard Walker. Sci. Am. Jan., '26.

c. Dams and Reservoirs

Period of Storage and Microörganisms in Reservoirs.* Robert Spurr Western. N. E. W. W. Assoc. Dec., '25.
Multiple-Arch Dam at Gem Lake on Rush Creek, California. Discussion: Luigi Luiggi, Thaddeus Merriman, M. M. O'Shaughnessy, J. B. Lilppincott, and Oren Reed. Am. Soc. C. E. Jan., '26.
Side Channel Spillways: Hydraulic Theory, Economic Factors, and Experimental Determination of Losses. Discussion: I. Gutmann and A. J. Wiley. Am. Soc. C. E. Jan., '26.
The Oradell Dam of the Hackensack Water Company.* Discussion: Stuart K. Knox, Howard T. Critchlow, and A. T. Ricketts. Am. Soc. C. E. Jan., '26.
Recent Italian Installations of Self-Acting Syphon Spillways.* Guido Ferro. Eng. Jan. 1, '26.
Failure of Dam in Wales Due to Washout Under Foundations.* Eng. N. R. Jan. 7, '26.
Kettenwehr, Kettenadelwehr, und selbstöffnendes Kettenadelwehr.* (Chain Weir, Chain Pin Weir, and Self-Opening Chain Pin Weir.) O. J. Herz. Oest. Ing. Arch. Ver. Nov. 27, '25.
Ermittlung der Schwingungen im Wasserschloss.* (Determination of Fluctuations in Reservoir Outlets.) Leiner. Ver. deu. Ing. Dec. 26, '25.

d. Analysis and Purification of Water

The Filtration Works of the City of Montreal.* Frederick E. Field. N. E. W. W. Assoc. Sept., '25.
Iodine and Water Supplies. Harry W. Clark. N. E. W. W. Assoc. Sept., '25.
Some Features of Filter Design. James W. Armstrong. N. E. W. W. Assoc. Sept., '25.
A Fineness Modulus for Filter Sands.* Richard G. Tyler. N. E. W. W. Assoc. Sept., '25.
A Score System for Grading Water Supplies According to Sanitary Conditions. E. Sherman Chase. N. E. W. W. Assoc. Sept., '25.
Studies of Differential Media for Detection of Bact. Coli in Water.* H. G. Dunham, H. M. McCrady and H. E. Jordan. Am. W. W. Assoc. Dec., '25.
Municipal Water Softening.* W. C. Hirn and E. F. Eldridge. (From *Public Health*, pub. by Michigan Dept. of Health.) Eng. & Contr. Dec. 9, '25.
A Score System for Grading Water Supplies According to Sanitary Conditions. E. Sherman Chase. N. E. W. W. Assoc. Dec. '25.
Proposed Secondary Chlorination of New York Water Supply After Leaving Open Reservoir at Hillview.* William W. Brush. Am. W. W. Assoc. Dec., '25.
Rapid Fine Sand Filtration.* Hiram W. Blaisdell. Am. W. W. Assoc. Dec., '25.
The Public Health Aspect of Stream Pollution. J. A. Childs. Am. W. W. Assoc. Dec., '25.
The Wheeling (West Virginia) Filtration Plant and Some Operating Results.* John F. Laboon. N. E. W. W. Assoc. Dec., '25.
Tastes in the Water Supply of Marquette, Mich., due to Phenol Wastes.* Paul Hansen. N. E. W. W. Assoc. Dec., '25.

e. Distribution of Water

Financing Main Pipe Extensions by the Assessment Method.* Caleb Mills Saville. N. E. W. W. Assoc. Sept., '25.
Selection of the Type of Power and Pumps for a Water Supply Company.* Cornell C. E. Dec., '25.
Price Trends Upon Centrifugal Pumps.* Leonard Metcalf. Am. W. W. Assoc. Dec., '25.
The New Sebago Lake Intake and Conduit of the Portland Water District.* Leonard Metcalf and Others. N. E. W. W. Assoc. Dec., '25.
The Problem of Water Supply for Fire Protection. V. Bernard Siems. Am. W. W. Assoc. Dec., '25.
Mechanical Equipment for Trench Excavation, Pipe Laying, and Backfilling. Thomas Brooks. Am. W. W. Assoc. Dec., '25.
Water Service Installation. George Read. Am. W. W. Assoc. Dec., '25.
Welding a Cracked 48-In Cast Iron Pipe Under 20 Feet of earth.* Wm. W. Brush. Am. W. W. Assoc. Dec., '25.
The New Little Quittacas Intake at New Bedford, Mass.* F. A. Barbour. N. E. W. W. Assoc. Dec., '25.
The Coolgardie Pipe Line in Australia, and Measures Taken to Correct Corrosion.* Francis F. Longley. N. E. W. W. Assoc. Dec., '25.
An Emergency Water Supply for Leominster, Mass. W. G. Classon and Charles W. Sherman. N. E. W. W. Assoc. Dec., '25.
Concrete Pump Pit Sunk as An Open Caisson.* B. Stanley Nelson. Eng. N. R. Dec. 31, '25.

Evaporation on United States Reclamation Projects.* Ivan E. Houk. Am. Soc. C. E. Jan., '26.
The Improved Venturi Flume.* Discussion: E. S. Lindley and C. E. Carter. Am. Soc. C. E. Jan., '26.

f. Drainage of Land

Permissible Canal Velocities.* Discussion: R. A. Hill, Jerome H. Fertig, E. S. Lindley, and Andrew Weiss. Am. Soc. C. E. Jan., '26.

x. Miscellaneous

Substitution of Machinery for Hand Labor in Pipe-Laying.* Stephen H. Taylor. N. E. W. W. Assoc. Dec., '25.

J. Sewerage. Sewage and Refuse Disposal

a. Sewers and Drains

Sewer Lining Experiments for Los Angeles County. A. M. Rawn. Eng. N. R. Jan. 7, '26.

b. Sewage Disposal, Purification

Sewage Disposal for Towns on Tidal Waters. D. Balfour. (From paper read before Royal Sanitary Inst.) Eng. & Contr. Dec. 9, '25.
A Plant for the Degreasing of Wool-Scouring Wastes.* George G. Bogren. Bost. Soc. Engrs. Jan., '26.
Stream Pollution. A Symposium. Discussion: Harrison P. Eddy. Am. Soc. C. E. Jan., '26.
Chlorine in Sewage and Waste Disposal. J. C. Baker. (From paper read before Am. Chem. Soc.) Can. Engr. Jan. 12, '26.
$101 028 000 Needed for Sewerage and Treatment at Detroit.* Eng. N. R. Jan. 21, '26.
Laboratoriumsversuche über den anaeroben Abbau des Klärschlammes.* (Laboratory Experiments on the Anaerobic Decomposition of Activated Sludge.) Bach. Gesund. Ing. Serial beginning Dec. 19, '25.

c. Refuse Disposal

Hydrogen-Ion Control in Chemical Treatment of Tannery Wastes.* Stuart E. Coburn. Bost. Soc. Engrs. Jan., '26.

x. Miscellaneous

Control of Odors from Sewage Treatment Plants. Discussion: John F. Skinner. Am. Soc. C. E. Jan., '26.

K. Heat Engines

a. Steam Engines, Boilers

Chaudières à Haute Pression.* (High Pressure Boilers.) Rev. Gen. Dec., '25.

L. Electricity

b. Distribution and Transmission of Electricity

2. Long-Distance Transmission of Energy
Les Sous-Stations Automates ou Semi-Automates.* (Automatic or Semi-Automatic Substations.) Gen. Civ. Dec. 12, '25.
5. Transformers and Converters
Power Transformers.* C. E. Sisson. Eng. Inst. Can. Jan., '26.

e. Electrochemistry and Electrometallurgy

Les Electrodes de Carbone pour l'Electrochimie et l'Electrométallurgie.* (Carbon Electrodes for Electrochemistry and Electrometallurgy.) Gen. Civ. Dec. 19, '25.

f. Signals and Communication

A. E. F. Telephone and Telegraph System.* Frank Homer Fay. Mil. Engr. Jan. Feb., '26.

M. Architecture

b. Business and Commercial Buildings

Neubauten der Deutschen Reichspost in Bayern.* (New Buildings for the German Government Post in Bavaria.) A. Gut. Z. d. Bauver. Dec. 9, '25.

c. Residences, Hotels

La Cité Ouvrière de l'Office Municipal d'Habitations à Bon Marché de Bordeaux.* (The Working People's City Built by the Bordeaux Municipal Department for Cheap Dwellings.) Jacques d'Welles. Gen. Civ. Dec. 5, '25.

x. Miscellaneous

Earthquake Expectancy in California.* Henry D. Dewell. Eng. N. R. Jan. 21, '26.

O. Administration. Legislation. Economics. Statistics

g. Engineering Education

Progress in the Study of Engineering Education.* W. E. Wickenden. Eng. N. R. Jan. 14, '26.

x. Miscellaneous

Engineering in a Small City—A Survey. Eng. N. R. Jan. 14, '26.

Q. Surveying and Geodesy

Eliminating Drag Effect in Triangulation.* William Bowie. Mil. Engr. Jan.–Feb., '26.

R. Landscape Engineering

Some How's and Why's of Good Planting.* Malcolm H. Dill. Land. Arch. Jan., '26.
Border Roads for Parkways and Parks. Frederick Law Olmstead. Land Arch. Jan., '26.

S. City Planning

Zoning, from a Residential View-Point.* Raymond A. Wheeler. Mil. Engr. Jan.–Feb., '26.
Zur Eweiterung der Durchfahrt beim Zeitglocken-Turm in Bern.* (Widening the Thoroughfare at the Clock-Tower in Bern.) Schw. Bauz. Dec. 19, '25.

Employment Service

The Engineering Societies Employment Service is under the joint management of the National Societies of Civil, Mining, Mechanical, and Electrical Engineers. A Chicago office is maintained in co-operation with the Western Society of Engineers, and a San Francisco office, in co-operation with the Engineers' Club of San Francisco and the California Section of the American Chemical Society. The Service is available only to the several memberships and is maintained by contributions from the Societies and their individual members who are directly benefited.

Offices.—Eastern Office, 33 West 39th Street, New York, N. Y., Walter V. Brown, Manager; Chicago Office, 53 West Jackson Boulevard, Room 1736, Chicago, Ill., A. Krauser, Manager; and San Francisco Office, 57 Post Street, Room 715, San Francisco, Calif., Newton D. Cook, Manager.

Men Available.—Under this heading, brief announcements will be published without charge. These announcements will not be repeated, except on request received after an interval of one month. Names and records will remain in the active files of the Service for a period of three months, and are renewable on request. Notices for *Proceedings* should be addressed to Employment Service, 33 West 39th Street, New York, N. Y., and should be received prior to the first of the month.

Opportunities.—A Bulletin of engineering positions available is published weekly and may be obtained by members of the Societies concerned at a subscription rate of $3 per quarter, or $10 per annum, payable in advance. Positions which are not filled promptly as a result of publication in the Bulletin, may be announced herein.

Voluntary Contributions.—Members obtaining positions through the medium of this Service are invited to co-operate with the Societies in the financing of the work by nominal contributions made within thirty days after placement, on the basis of $10 for all positions paying a salary of $2 000 or less per annum; $10 plus 1% of all amounts in excess of $2 000 per annum; temporary positions (of one month or less), 3% of total salary received. The income contributed by the members, together with the finances appropriated by the four Societies named, will be sufficient, it is hoped, not only to maintain but to increase and extend the service.

Replies to Announcements.—Replies to announcements published herein, or in the Bulletin, should be addressed to the key number indicated in each case, with a two-cent stamp attached for re-forwarding, and forwarded to the Employment Service at the address given. Replies received by the Service after the positions to which they refer have been filled, will not be forwarded.

MEN AVAILABLE

LICENSED PROFESSIONAL ENGINEER AND LAND SURVEYOR, New York, M. Am. Soc. C. E.; age 49; married. Thirty years' experience on highways, pavements, sewers, and other municipal work. Experienced executive. Available as municipal engineer or manager. Salary $4 500. Location preferred, Atlantic or Central States. A-1505.

CIVIL ENGINEER, Assoc. M. Am. Soc. C. E. Twenty years' experience, municipal lines, land subdivision, roads and streets, water, sewers and sewage disposal, city planning, oil storage, steel tank and earth reservoir, irrigation and reclamation systems, concrete structures, both design and construction. Available at once. B-4769.

CONSTRUCTION OR OPERATING SUPERINTENDENT, Assoc. M. Am. Soc. C. E.; age 37; married. More than five years' experience in South and Central America, Mexico, and Santa Domingo on dam, general building, and railroad construction and operation; also experience as marine superintendent for fruit company. Speaks Spanish and understands tropical conditions. For the past two years with Hugh L. Cooper, M. Am. Soc. C. E., on the construction of Wilson Dam and Power House. Desires position as Construction Superintendent or Assistant. B-5296.

CIVIL ENGINEER, M. Am. Soc. C. E.; age 36; graduate civil engineer; registered Professional Engineer in Pennsylvania. Now chief engineer, engineering and contracting firm specializing in design and construction of power houses, reinforced concrete buildings, bins, industrial plants. Sixteen years' experience in design and construction of railroads, docks, coal and coke-handling systems, and coke oven plants. Available on reasonable notice. Eastern or Southern location preferred. C-795.

CIVIL ENGINEER, Assoc. M. Am. Soc. C. E.; now in Eastern Florida, desires connection with development company, municipality or contractor, as office engineer. Fifteen years' experience in railroad, town-site development, and highway work as office and field engineer. Able to design and direct work. Registered in Florida and Pennsylvania. C-800.

CIVIL ENGINEER, Assoc. M. Am. Soc. C. E.; University graduate; age 47. Experienced in design and construction of railroads, public utilities, reinforced concrete buildings. Dams and irrigation structures a specialty. C-847-1-A-18.

Membership

(From January 6, to February 2, 1926)

Additions

		Date of Membership.
ANDREWS, Joseph. Instr., Dept. of Civ. Eng., Sheffield Scientific School, Yale Univ., Box 151, West Haven, Conn.	Jun.	Jan. 18, 1926
ANSLEY, Willis Partman. Draftsman, Koppers Constr. Co. (Res., 828 Ridge Ave., N. S.), Pittsburgh, Pa.	Jun.	Jan. 18, 1926
BATEMAN, John Henry. Research Prof., Highway Eng., Louisiana State Univ., Baton Rouge, La.	Assoc. M. M.	Jan. 19, 1920 Jan. 18, 1926
BEDNARSKI, Edward Joseph. Draftsman, Great Western Power Co., 530 Bush St., San Francisco, Calif.	Assoc. M.	Dec. 14, 1925
BEECHLEY, Edgar Homer. Asst. Engr., U. S. Engrs., Pittsburgh, Pa.	M.	Dec. 14, 1925
BEYER, Adam Carl. Asst. City Engr. (Res., 811 Fifth Ave.), San Rafael, Calif.	Jun.	Dec. 14, 1925
BLINN, Ray Sharp. Cons. Engr., 500 Faulkner St., New Smyrna, Fla.	M.	Dec. 14, 1925
BROOKS, Thomas. Asst. Supt., City Water Dept. (Res., 2045 North Catalina St.), Los Angeles, Calif.	M.	Dec. 14, 1925
BROSSARD, Louis Fisher. Draftsman, Am. Bridge Co., 757 Polk St., Gary, Ind.	Jun.	Dec. 14, 1925
BROWN, Hoyt Cuthbert. Chf. Engr., Daytona Highlands Co., Inc., Daytona (Res., 511 South Ridgewood Ave., Daytona Beach), Fla.	Jun.	Jan. 18, 1926
BRYANT, Charles Byrn. Service Engr., Portland Cement Assoc., 421 Union Trust Bldg., Washington, D. C.	Jun.	Dec. 14, 1925
BUCK, Henry Wolcott. Structural Draftsman, Dwight P. Robinson Co., Inc., 125 East 46th St., New York, N. Y.	Jun.	Dec. 14, 1925
BURKE, Edward John. Deck Officer, U. S. Coast and Geodetic Survey ship, *Bache*, P. O. Box N, St. Petersburg, Fla.	Jun.	Dec. 14, 1925
BURR, George Danforth. Asst. Engr., King County Engr.'s Office, 536 County-City Bldg., Seattle, Wash.	Jun.	Dec. 14, 1925
BUTLER, Herbert Fuller. Estimator, Kalman Steel Co., 110 East 42d St., New York (Res., 20 Earle Pl., New Rochelle), N. Y.	Jun. Assoc. M.	Aug. 28, 1922 Jan. 18, 1926
CHRISTIAN, Francis Griffith. With Tallassee Power Co., Box 161, Badin, N. C.	Jun.	Oct. 12, 1925
COTTON, Edwin Rowland. Fort Pierce, Fla.	Jun.	Oct. 12, 1925
CRAWFORD, Hugh Lindesay. Asst. Engr., U. S. Bureau of Reclamation (Res., 254 South Oakley Ave.), Burley, Idaho.	Assoc. M.	Dec. 14, 1925
DAVENPORT, George Lyman, Jr. Asst. Engr., A. T. & S. F. Ry. (Res., 1430 West 52d St.), Los Angeles, Calif.	M.	Dec. 14, 1925
DAVIS, Calvin Victor. Designing Engr., Ambursen Constr. Co., Inc., 2520 Grand Central Terminal, New York, N. Y.	Assoc. M.	Dec. 14, 1925
DE OLIVEIRA Penteado, Joaquim Timotheo. Insp. Gen., Bureau of Constr. and Maintenance, State Highways, State of São Paulo, Rua Bartyra 15, São Paulo, Brazil.	M.	Dec. 14, 1925
DIXON, William Joseph. Public Health Engr., Dept. of Health, Chattanooga, Tenn.	Jun.	Dec. 14, 1925
DOEBLER, Horatio Ward. Draftsman, Turner Constr. Co., New York, N. Y. (Res., 321 Fairmount Ave., Jersey City, N. J.)	Jun.	Dec. 14, 1925
DOWD, Munson Julius. Gen. Supt., Imperial Irrigation Dist., Imperial, Calif.	Jun. Assoc. M.	Jan. 13, 1919 Dec. 14, 1925
FOREMAN, Charles Ernest. With The Reading Co. of Philadelphia, Central Y. M. C. A., 1425 Arch St., Philadelphia, Pa.	Jun.	Oct. 12, 1925
FOWLER, William Edward. Chf. Engr., Montana R. R. Pittsburgh (Res., 315 Meadow Lane, Edgeworth, Sewickley), Pa.	M.	Jan. 18, 1926
FOX, William Joseph. City Engr., City Hall, South Pasadena, Calif.	Assoc. M.	Dec. 14, 1925
FRIEL, Francis de Sales. Civ. and San. Engr., Albright & Mebus, 1502 Locust St., Philadelphia, Pa.	Assoc. M. M.	Jan. 17, 1921 Jan. 18, 1926
FUQUA, Lawrence Franklin. Junior Engr., City of Houston, 208 City Hall, Houston, Tex.	Jun.	Oct. 12, 1925
GERMUNDSSON, Thorbjörn. Designer and Detailer, Kalman Steel Co., Chicago (Res., 235 South Elmwood St., Oak Park), Ill.	Assoc. M.	Dec. 14, 1925
GIST, John C. Constr. Engr., Ross Constr. Co., Box 906, Arcadia, Calif.	Assoc. M.	Dec. 14, 1925
GLUCKERT, William John, Jr. Chf. of Party, Franklin & Co. (Res., 1046 South Paxon St.), Philadelphia, Pa.	Jun.	Jan. 18, 1926
GORE, William. Cons. Civ. Engr. (Gore, Nasmith & Storrie), 625 Confederation Life Bldg., Toronto, Ont., Canada.	M.	Jan. 18, 1926
GRAND, Harris. Junior Asst. Engr., Grade 1, State Bureau of Highways, 571 Hendrix St., Brooklyn, N. Y.	Jun.	Jan. 18, 1926
GRIGGS, Austin B. Valuation Engr., A. T. & S. F. Ry., Room 416, Santa Fé Gen. Office Bldg., Topeka, Kans.	M.	Jan. 18, 1926
HABERSHON, Matthew Edmund. Eng. Asst., Borough Engr.'s Dept., Rotherham Corporation, Ferham Villa, Rotherham, England.	Jun.	Dec. 14, 1925

MEMBERSHIP—(*Continued*)

		Date of Membership.
HANLY, Hunter Wardlaw. Structural Engr. (Euphrat & Hanly), Cincinnati (Res., 4915 Pine St., Norwood), Ohio	M.	Jan. 18, 1926
HARVEY, Bernhard Carl. Public Engr., City of Rockford, City Hall, Rockford, Ill	Assoc. M.	Jan. 18, 1926
HASKELL, Llewellyn Gilmore. Dist. Engr., Pipe Line Dept., Standard Oil Co. of California, Box 107, Hynes, Calif	Jun. Assoc. M.	Oct. 10, 1921 Dec. 14, 1925
HAWTHORN, George Edward. Instr., Civ. Eng., Univ. of Washington (Res., 4205 Frances Ave.), Seattle, Wash	Assoc. M.	Oct. 12, 1925
HEWSON, Reginald Joseph Bedford. Chf. Engr., Jamaica Govt. Ry., Kingston, Jamaica	M.	Aug. 31, 1925
HUFF, Van Ellis. Civ. Engr., 229 Republic Bldg., Miami, Fla.	Assoc. M.	Jan. 18, 1926
HUNTER, Ralph Waldo. Supt. of Constr., G. F. Young, 1527½ Grand Central Ave., Tampa, Fla	Assoc. M.	Dec. 14, 1925
IMMERMAN, Harry Treadwell. Chf. Designing Engr., Spencer, White & Prentis, Inc., 709 Sixth Ave. (Res., 720 West 170th St.), New York, N. Y	M.	Jan. 18, 1926
JENKINS, Kendall Reed. Junior Engr., Standard Oil Co., 1218 Standard Oil Bldg., San Francisco, Calif	Jun.	Dec. 14, 1925
KAUFMAN, Morris Lewis. Cons. Engr., 469 Seventh Ave., New York, N. Y	M.	Jan. 18, 1926
KINNISON, Harvey Banks. Hydr. Engr., U. S. Geological Survey 23 Federal Bldg., Topeka, Kans	Assoc. M.	Dec. 14, 1925
KINSEY, Leon Browning. (Kinsey Eng. Co.), Pekin, Ill	M.	Jan. 18, 1926
KNIGHT, Merrill Donnaldson, Jr. Prin. Asst. Engr., Dept. of Public Works, Bureau of Eng., 1015 Federal St., Lynchburg, Va	Assoc. M.	Jan. 18, 1926
LAVERTY, Francis John. 19 Tompkins Ave., Mamaroneck, N. Y	Jun.	Oct. 12, 1925
LEISER, Ferdinand. Mgr., Estimating Dept., White Constr. Co., 95 Madison Ave., New York (Res., 62 Twenty-third St., Jackson Heights), N. Y	Jun. Assoc. M. M.	June 24, 1914 Oct. 11, 1920 Jan. 18, 1926
McCASHIN, Clarence Eugene. Associate Engr., U. S. Geological Survey, Box V, Capitol Station, Austin, Tex	Assoc. M.	Jan. 18, 1926
McCLURE, Wilbur Fisk. Director of Public Works and State Engr. of California (Res., 1047 Forty-seventh St.), Sacramento, Calif	M.	Dec. 14, 1925
McMORRIS, William Barnhart. Rodman, Gilbert C. White Co., Box 357, Asheville, N. C	Jun.	Oct. 12, 1925
MAHON, Albert Anthony. Engr., Union Paving Co., 30th and Locust St. (Res., 3743 Walnut St.), Philadelphia, Pa	Assoc. M.	Dec. 14, 1925
MARSDEN, Raymond Robb. Dean, Thayer School, and Prof., Civ. Eng., Dartmouth Coll., Hanover, N. H	Assoc. M. M.	Jan. 19, 1920 Jan. 18, 1926
MEADOWCROFT, Allan James. Box 1134, Standford University, Calif	Jun.	Jan. 18, 1926
MILLER, John Owen. Asst. Engr., Dept. of Public Works, (Res., 3306 Colonial Ave.), Norfolk, Va	Jun. Assoc. M. M.	July 2, 1913 Jan. 14, 1918 Jan. 18, 1926
MOORE, Paul Ross. City Engr., City Hall, Fort Pierce, Fla	Assoc. M.	Jan. 18, 1926
MOSHER, Sidney Wood. Civ. Engr., Member of Examining Board of Municipal Civil Service Comm. of New York City, Room 1428 Municipal Bldg., New York, N. Y	Assoc. M.	Jan. 18, 1926
MUTH, Frank Amende. First Asst. Supt., U. S. Lighthouse Service, Room 224, Custom House Bldg., New Orleans, La	Assoc. M. M.	Oct. 10, 1916 Jan. 18, 1926
OLSON, Oliff Neil. 219 North 23d, Corvallis, Ore	Jun.	Oct. 12, 1925
PALMER, Arthur Carl. Transitman, The Reading Co. Y. M. C. A., Reading, Pa	Jun.	Dec. 14, 1925
POWELL, John Edward Charles. Draftsman, H. S. Swan, 15 Park Row, New York (Res., 365 Sandol St., Brooklyn), N. Y	Jun.	Jan. 18, 1926
PUGSLEY, Edmond Folsom. Vice-Pres. and Gen. Mgr., Cascade Pipe & Flume Co., Box 812, Seattle, Wash	Assoc. M.	Dec. 14, 1925
QUISLING, Arne. Draftsman, G. Lindenthal, 36 Garden Pl., Brooklyn, N. Y	Jun.	Oct. 12, 1925
RIIS, Laurence Johannus Jensen. Valuation Engr., Barker & Wheeler, 90 West St., New York, N. Y. (Res., 875 Boulevard East, Weehawken, N. J.)	Jun.	Aug. 31, 1925
ROSE, Harry Frederic. Eng. Draftsman, N. Y. C. R. R., 466 Lexington Ave., New York (Res., 411 East 51st St., Brooklyn), N. Y	Jun.	Dec. 14, 1925
RIVERO, Juan Ramon. Civ. Engr., Casilla 2, La Paz, Bolivia	Assoc. M.	Aug. 31, 1925
ROBINSON, Onslow Stewart. Draftsman, Parklap Constr. Corporation (Res., 701 Ingleside Ave.), St. Petersburg, Fla	Jun.	Jan. 18, 1926
ROSS, Conrad Milton. Asst. City Engr., 711 Orange St., Charleston, W. Va	Assoc. M.	Jan. 18, 1926
ROTHI, Paul. 1044 Fries Ave., Wilmington, Calif	Assoc. M.	Dec. 14, 1925
SAMUEL, Philip Tustin. Asst. Chf. of Supply Div., U. S. Engr. Office, Florence, Ala	Affiliate	Dec. 14, 1925
SCHMIDT, Edward Carl. Draftsman, Third Ave. Ry., 258 Argyle Rd., Brooklyn, N. Y	Jun.	Dec. 14, 1925

MEMBERSHIP—(*Continued*)

		Date of Membership.
SPADA, John Anthony. Eng. Asst., Westchester County Park Comm., Locust Ave., Scarsdale, N. Y.	Jun.	Dec. 14, 1925
STAFFORD, Julian Tate. Steel Detailer, Am. Bridge Co. (Res., 448 Marshall St.), Gary, Ind.	Jun.	Dec. 14, 1925
STAUBITZ, Edward Julius. Engr., Milliken Bros. Mfg. Co., Inc., Woolworth Bldg. (Res., 2639 Jerome Ave.), New York, N. Y.	Assoc. M.	Jan. 18, 1926
STOUT, Erl Wayne. Box 101, Arcadia, Fla.	Assoc. M.	Dec. 14, 1925
TAPLEY, George Manning. Junior Engr., U. S. Engr. Office, Custom House, Louisville, Ky.	Jun.	Dec. 14, 1925
THEIMER, Otto Frederick. Asst. to Gustav Lindenthal (Res., 415 West 118th St.), New York, N. Y.	Assoc. M.	Jan. 18, 1926
TILTON, Claire Eugene. Municipal and San. Engr., 211 Accho Bldg., Phillipsburg, N. J.	Assoc. M.	Dec. 14, 1925
TOWNE, Lockwood Janes. Structural Engr., Stone & Webster, Inc., 147 Milk St., Boston, Mass.	Assoc. M. M.	Dec. 5, 1911 Jan. 18, 1926
VAN DER NOORDAA, Johan Taco. Designing Draftsman, George F. Hardy, 309 Broadway, New York, N. Y.	Jun.	Dec. 14, 1925
VAWTER, Jamison. Asst. Prof., Civ. Eng., Univ. of Illinois, 217 Eng. Hall, Univ. of Illinois, Urbana, Ill.	Assoc. M. M.	Jan. 15, 1923 Jan. 18, 1926
WALSH, Jeremiah Mark John. 201 West 3d Ave., Roselle, N. J.	Assoc. M.	Dec. 14, 1925
WARK, James Evert. Surveyman, U. S. Lake Survey, 311 Old Custom House (Res., 979 Reed Pl.), Detroit, Mich.	Jun.	Dec. 14, 1925
WEIL, Herbert Louis. Material Tester, State Highway Dept. (Res., 1218 Washtenaw), Ann Arbor, Mich.	Jun.	Jan. 18, 1926
WELTY, Perry Allen. Civ. Engr.; Cons. Engr., Wichita County Water Impvt. Dists., 1006 Staley Bldg. (Res., 1711 Eleventh St.), Wichita Falls, Tex.	Assoc. M. M.	Mar. 12, 1918 Jan. 18, 1926
WILLIAMSON, George Morrison. Archt.-Engr., 515 Sunshine Bldg., Albuquerque, N. Mex.	Assoc. M. M.	Jan. 19, 1920 Jan. 18, 1926
WOOTTEN, Alfred Gerald. 224 West 71st St., New York, N. Y.	Jun.	Aug. 31, 1925
WRIGHT, Francis James. Box 533, Pearl River, N. Y.	Assoc. M.	Dec. 14, 1925

Reinstatements

MEMBERS

	Date of Reinstatement
CRANE, Joseph Spencer	Jan. 18, 1926
HENSHAW, Fred Forbes	Jan. 18, 1926
McLOUD, Paul	Jan. 18, 1926
THOMAS, Edgar Branson	Jan. 18, 1926

ASSOCIATE MEMBERS

BARNARD, Elmer Ellsworth	Jan. 18, 1926
DIRATS, Janik Kevork	Jan. 18, 1926
WALKER, Joseph Jeanes	Jan. 18, 1926

Deaths

METCALF, Leonard. Elected Associate Member, January 5, 1898; Member, September 2, 1903; died January 29, 1926.

STEIN, Milton Frederick. Elected Associate Member, December 3, 1912; Member September 9, 1919; died January 2, 1926.

WOLF, Julius Herman George. Elected Associate Member, May 7, 1902; Member, April 5, 1904; died December 19, 1925.

Total Membership of the Society, February 2, 1926

Members	**5 071**	
Associate Members	**5 273**	
Corporate Members		**10 344**
Honorary Members		**15**
Juniors		**853**
Affiliates		**151**
Fellows		**8**
Total		**11 371**